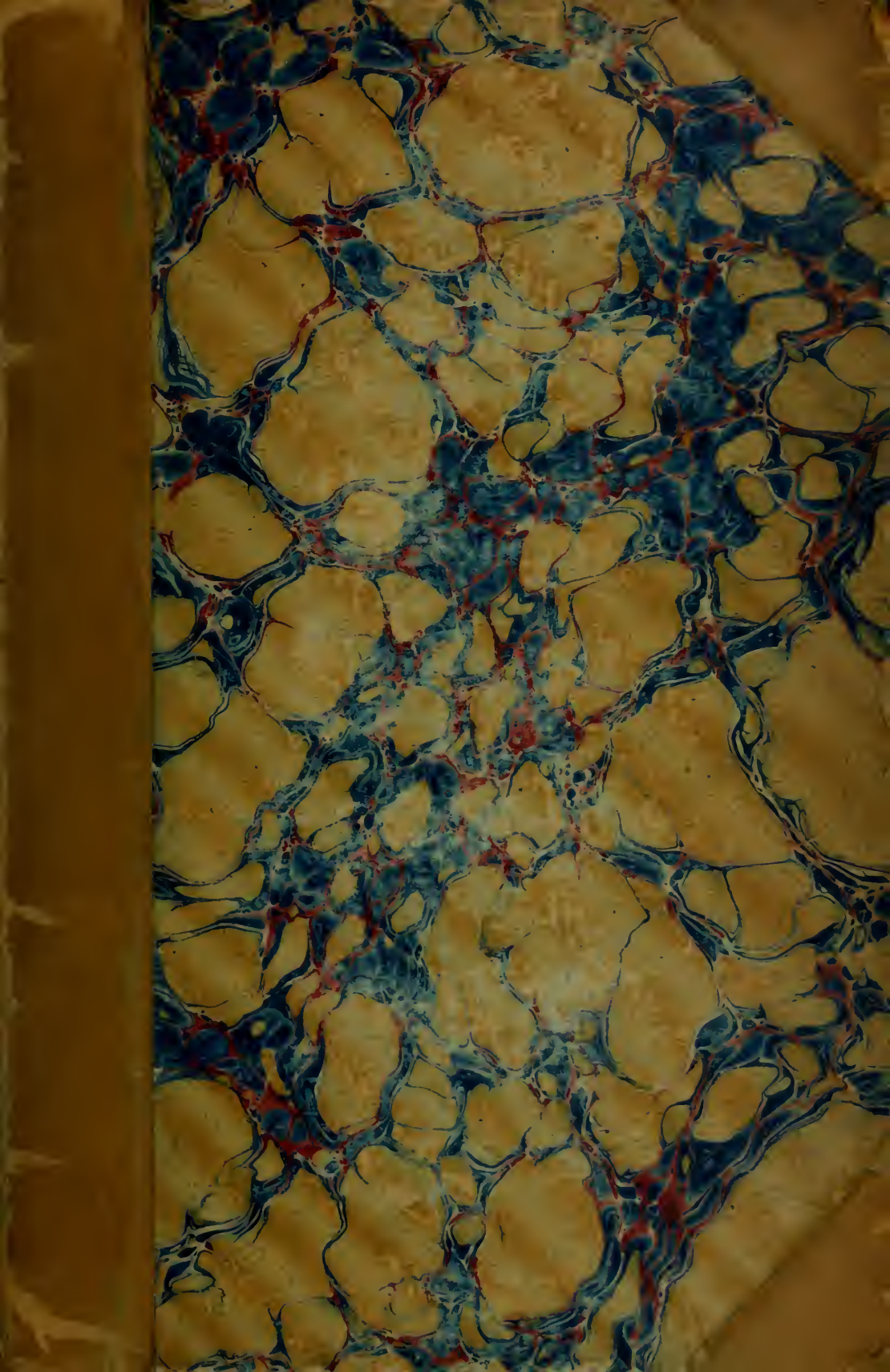




*P
Tech
F*

THE JOURNAL

—OF THE—

FRANKLIN INSTITUTE,

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

Chas. Bullock, Prof. Persifor Frazer, D.Sc., Prof. Edwin J. Houston, Theo.

D. Rand, Prof. Coleman Sellers, Committee on Publication :

with the Assistance of

Dr. Wm. H. Wahl, Secretary of the Institute.

COLLABORATORS:

Prof. L. D'Auria,

Prof. Geo. A. Koenig,

Prof. M. B. Snyder,

Prof. Wm. H. Greene,

Otto Lüthy,

H. W. Spangler, U.S.N.,

Prof. Lewis M. Haupt,

Prof. Wm. D. Marks,

Prof. Henry Trimble,

Prof. Chas. F. Himes,

Prof. S. P. Sadtler,

Carl Hering.

VOL. CXXVI.—Nos. 751-756.

THIRD SERIES,

VOL. XCVI.—JULY TO DECEMBER, 1888.

PHILADELPHIA :

Published by the Institute, at the Hall, 15 South Seventh Street.

1888.

621229
21.10.23

JOURNAL OF THE FRANKLIN INSTITUTE.

Vol. CXXVI.

INDEX.

Actinometer, Electro-Chemical, An. (Gouy and Rigollet), ...	416
Air Currents, Movement of Upper. (Hazen), ...	45
Ajax Metal Company's Process of Cleansing, Preparing and Coating Metal Sur- faces, Report of the Committee on Science and the Arts, on, ...	73
Alkali Waste, Recovery of Sulphur from. (Chance), ...	261
Aluminium. (Henderson), ...	273
and its Alloys, Relative Value of, in the Arts. (Pemberton, Jr.), ...	265
and its Alloys, Relative Value of in the Arts. A Correction (Pemberton, Jr.), ...	369
Influence of, upon Cast Iron. (Keep, Maybery and Vorce), ...	220
Animal Chlorophyl. (MacMunn), ...	497
Astronomical Coincidences, Two Remarkable. (D'Auria), ...	295
Bache, R. Meade. Description of a Safety Car Heater, ...	145
Safety Car Heater, Report of Committee on Science and the Arts, on, ...	143
Beauman, A. W. Efficiency of Steam at High Pressures, ...	495
Birkinbine, John. The Iron Ores of the United States, ...	190
Bodley, Rachel L., Obituary Notice of, ...	69
<i>Book Notices :</i>	
Ashcroft Company's Improved Tabor Indicator, ...	255
Collection des Anciens Alchimistes Grecs. (Berthelot), ...	79
Chronicle Fire Tables, for 1888, ...	251
Accidents and Emergencies. (Dulles), ...	493
History of Insurance in Philadelphia for Two Centuries. (Fowler), ...	252
Fundamental Principles of Chemistry. (Galloway), ...	250
Compressive Resistance of Freestone, Brick Piers, Cements, etc. (Gillmore), ...	247
Preparing for Indication. (Grimshaw), ...	414
Geological Evidences of Evolution. (Heilprin), ...	494
Plate Girder Construction. (Herol), ...	493
Leitfaden für den Unterricht im Schiffbau. (Hüllen, Van), ...	254
Storage Reservoirs. (Jacob), ...	415
Darwinism. (Jordan), ...	492
Practical Hints for Draughtsmen. (MacCord), ...	76
A Few Incidents in the Life of James P. Espy. (Moreland), ...	413
Tables of the Properties of Saturated Steam, etc. (Peabody), ...	412
Manual of Descriptive Geometry. (Waldo), ...	411
Elementary Course in Descriptive Geometry. (Woolf), ...	415
Booth, James Curtis, Obituary Notice of, ...	67
Bornstein, E. Detection of Commercial Saccharin in Articles of Food, ...	416
Bow Girders, Jointed. (Werner), ...	53, 232, 317

T
1
F8
v. 126

Bridge, Pontoon, at Nebraska City, ...	339
Steel on the Northern Pacific Railroad, Note on a Danger to, ...	340
Broader Field, A, for the United States Geological Survey. (Frazer), ...	208
Bronze of Japanese Magic Mirrors, Composition of, ...	500
Brown, Allan D. The Electrical Distribution of Time, ...	14
 Calorimeter, A New. (Peabody), ...	134
Canal, Nicaragua, The, ...	340
Panama, The. (<i>Engineering News</i>), ...	341
Car Heater, Safety, Description of a. (Bache), ...	145
The Bache, Report of Committee on Science and the Arts, on, ...	143
Carbutt, John. A Perfect Substitute for Glass as a Support for Gelatine Bromide of Silver for Use in Photography, ...	478
Cast Iron, Influence of Aluminium upon. (Keep, Mabery and Vorce), ...	220
Chance, Alex. M. Recovery of Sulphur from Alkali Waste, by Means of Lime- Kiln Gases, ...	261
Chlorine, Manufacture of, The Weldon-Pechiney Process for. (Dewar), ...	420
Chlorophyl, Animal. (MacMunn), ...	497
Clamer's Process of Cleansing and Coating Metal Surfaces, Report of the Com- mittee on Science and the Arts, on, ...	73
Coincidences, Astronomical, Two Remarkable. (D'Auria), ...	295
<i>Correspondence</i> —C., L.E. National Public Works, ...	244
Reply to Capt. Turtle. (Haupt), ...	140
Photographs of Lightning. (Jennings), ...	491
Improvement of Sabine Pass. (Turtle), ...	137, 246
Crafts, J. M. Action of Mercury on Platinum, ...	419
Purification of Mercury, ...	416
Cupolas for Melting Pig Iron, Construction of Various Kinds of. (Gouvy), ...	425
Cutch and Gambier. (Trimble), ...	417
Cylinders for Successive Expansion Engines, To Determine the Sizes of. (Gow), ...	258
 D'Auria, L. Two Remarkable Astronomical Coincidences, ...	295
Decline of Engineering, The. (Le Van), ...	25
Delaware River, Removal of Islands in, ...	339
Dewar, J. The Weldon-Pechiney Process for the Manufacture of Chlorine, ...	420
Dougherty Railroad Signal, The Report of the Committee on Science and the Arts, on, ...	335
Dudley, Chas. B. Fuel Oil, ...	81
Durfee, W. F. (<i>Gouvy</i>) Construction of Various Kinds of Cupolas for Melt- ing Pig Iron, ...	425
 Electric Furnaces, Early Forms of. (Houston), ...	64, 215
Electric Welding. (Thomson), ...	399
(Woodbury), ...	471
Electrical Distribution of Time, The. (Brown), ...	14
Electricity, Protection of Buildings against Water Overflows by. (Weil), ...	330
Electro-Chemical Actinometer, An. (Gouy and Rigollet), ...	416
Elevated Road, Philadelphia, The Reading Terminal, ...	496
Engineering, Decline of, The. (Le Van), ...	25

Engines, Distribution of Internal Friction in. (Thurston), ...	370
Successive Expansion, To Determine the Sizes of Cylinders for. (Gow), ...	258
Vibrating. Lidback, ...	337
Exposures, Instantaneous, Photographic, Determining Absolute Time of. (Levi-son), ...	162
Eye, Photograph of the Human, by Magnesium Flash Light. (Reymond), ...	162
Films, Insoluble Gelatine in Emulsion Photography. (Stieglitz), ...	162
Food, Detection of Commercial Saccharin in. (Bornstein), ...	416
FRANKLIN INSTITUTE—Committee on Science and the Arts. Report on the Bache Safety Car Heater, ...	143
Committee on Science and the Arts. Report on Clamer's Process of Cleansing and Coating Metal Surfaces, ...	73
Committee of Science and the Arts. Report on the Dougherty Railroad Signal, ...	335
Committee on Science and the Arts. Report on the Hyatt Pure Water System, ...	71
Committee on Science and the Arts. Report on Lance's Method of Utilizing Oil-Cloth Waste, ...	334
Committee on Science and the Arts. Report on the Simond's Universal Metal Rolling Machine, ...	345
Committee on Science and the Arts. Report on Ziegler's Patent Trestle and Scaffold System, ...	149
Gifts to the Library, ...	164, 262, 342, 420, 502
Proceedings of the Stated Meetings, June to November, 1888, ...	168, 344, 423, 504
Frazer, Persifor. A Broader Field for the U. S. Geological Survey, ...	208
Obituary Notice of H. C. Lewis, ...	154
of Rachel L. Bodley, ...	69
Friction, Internal, of Engines, Distribution of. (Thurston), ...	370
Fuel Oil. (Dudley), ...	81
Furnaces, Electric, Early Forms of. (Houston), ...	64, 215
Gambier and Cutch. (Trimble), ...	417
Gelatine Bromide of Silver, A Substitute for Glass as a Support for Use in Pho- tography. (Carbutt), ...	478
Gelatine Films, Insoluble, as a Substitute for Glass in Emulsion Photography, (Stieglitz), ...	162
Geographical Congress, International, in Paris, ...	163
Geological Survey, U. S., A Broader Field for the. (Frazer), ...	208
Gieseler, E. A. Standard Measures, ...	115
Girders, Continuous, Indeterminate Multipliers for the. (Lindenberger), ...	465
Girders, Jointed Bow, General Theory of. (Werner), ...	53, 232, 317
Glass as a Support for Gelatine Bromide of Silver, A Substitute for. Use in Pho- tography. (Carbutt), ...	478
Glass, Insoluble Gelatine Films as a Substitute for, in Emulsion Photography. (Stieglitz), ...	162
Gouvy, M. A. An Investigation of the Construction of Various Kinds of Cupolas for Melting Pig Iron, ...	425

Gouy and H. Rigollet. An Electro-Chemical Actinometer, ...	416
Gow, John L. The Zeuner Valve Diagram, ...	255
To determine the Sizes of Cylinders for Successive Expansion Engines, ...	258
Gump, W. E. The Writing Telegraph, ...	297
Haupt, Lewis M. Feasibility of Underground Railroads in Philadelphia, ...	448
Reply to Capt. Turtle's Communication on the Sabine Pass, ...	140
Hazen, H. Allen. Movement of Upper Air Currents, ...	45
Heater, Safety Car, Bache, Report of Committee on Science and the Arts, on, .	143
Description of a. (Bache), ...	145
Helme, William, Obituary Notice of, ...	155
Henderson, Hanford. Aluminium, ...	273
Houston, Edwin J. On Some Early Forms of Electric Furnaces, ...	64, 215
Hyatt Pure Water System, Report of the Committee on Science and the Arts, on,	71
Hydrogen Iodide, Preparation of. (Meyer), ...	260
Indigo in China, Production of, ...	502
International Congress of Geologists. Note to Libraries and Individuals, . . .	80
Geographical Congress in Paris, ...	163
Iron Ores of the United States, The. (Birkinbine), ...	190
Isherwood, B. F. (Pictet.) Determination of a Definition of Temperature, . .	212
Japanese Magic Mirrors, Composition of the Bronze of, ...	500
Jennings, W. N. Photographs of Lightning, ...	491
Keep, W. J., C. F. Mabery and L. D. Vorce. The Influence of Aluminium upon Cast Iron, ...	220
Kent, Wm. Weighing Machines, ...	169
Lance's Method of Utilizing Oil-Cloth Waste, Report of the Committee on Science and the Arts, on, ...	334
Landslide, Danger to a Bridge on the Northern Pacific Railroad from, ...	340
Le Van, Wm. B. Is Engineering on the Decline?	25
Levison, W. G. Determining the Absolute Time of Instantaneous Photographic Exposures, ...	162
Lewis, Henry Carvill, Obituary Notice. (Frazer), ...	154
Lidback's Vibrating Engine, ...	337
Lightning, Photographs of. (Jennings), ...	491
Lindenberger, C. H. Indeterminate Multipliers for the Continuous Girder, . .	465
Lustre, Metallic, Cause of. (Spring), ...	419
Mabery, C. F. See Keep, W. J., ...	220
MacMunn, C. A. Animal Chlorophyl, ...	497
Magic Mirrors, Japanese, Composition of Bronze of, ...	500
Magnesium Flash Light, Photograph of the Eye, by, ...	162
Powder for Photographic Purposes, ...	162
Mason, Geo. C., Jr. Memoir of Thomas Ustick Walter, ...	404
Measures, Standard. (Gieseler), ...	115

Mercury, Action of, on Platinum. (Crafts), ...	419
Purification of. (Crafts), ...	416
Menocal, A. G. The Nicaragua Canal, ...	340
Metal Rolling Machine, The Simonds', Report of the Committee on Science and the Arts, on, ...	345
Metal Rolling Machine, The Simonds', ...	1
Surfaces, Cleansing and Coating, The Ajax Metal Company's Process of, Report of the Committee on Science and the Arts, on, ...	73
Metallic Lustre, Cause of. (Spring), ...	419
Meyer, Lothar. Preparation of Pure Hydrogen Iodide, ...	260
Victor. Preparation and Properties of Nitrogen Chloride, ...	498
Mirrors, Japanese Magic, Composition of the Bronze of, ...	500
Movement of Upper Air Currents. (Hazen), ...	45
National Public Works, ...	157, 244
Nicaragua Canal, The, ...	340
Nitrogen Chloride, Preparation and Properties of. (Meyer), ...	498
Note to Libraries and Individuals. (International Congress of Geologists), ...	80
Obituary. Rachel L. Bodley, ...	69
James Curtis Booth, ...	67
William Helme, ...	155
Henry Carvill Lewis, ...	154
Thomas U. Walter, ...	404
Joseph Zentmayer, ...	483
Oil-Cloth Waste, Lance's Method of Using, Report of the Committee on Science and the Arts, on, ...	334
Oil, Fuel. (Dudley), ...	81
Panama Canal, The. (<i>Engineering News</i>), ...	341
Paris Universal Exposition, 1889, ...	500
Peabody, Cecil H. A New Calorimeter, ...	134
Pemberton, H., Jr. An Inquiry into the Relative Value of Aluminium and its Alloys to the Arts, ...	265, 369
Pennsylvania State Weather Service. Monthly Weather Review. May to October, 1888. (<i>Supplement</i> , July to December.)	
Petroleum "Sludge" Acid, Utilization of. (Thompson), ...	260
Philadelphia, Port of, Removal of Islands in, ...	339
Underground Railroads in, Feasibility of. (Haupt), ...	448
Photographic Exposures, Instantaneous, Determining Absolute Time of. (Levi-son), ...	162
Photographs of Lightning. (Jennings), ...	491
Photographs of the Eye by the Magnesium Flash Light. (Reymond), ...	162
Photography, Emulsion, Insoluble Gelatine Films as a Substitute for Glass in. (Stieglitz), ...	162
Photography, A Substitute for Glass as a Support for Gelatine Bromide of Silver for Use in. (Carbutt), ...	478
Pig Iron, Cupolas for Melting, Construction of Various Kinds of. (Gouvy), ...	425

Pictet, Raoul. Theoretical and Experimental Determination of a Definition of Temperature, ...	212
Platinum, Action of Mercury on. (Crafts), ...	419
Pontoon Bridge at Nebraska City, The, ...	339
Protection of Buildings Against Water Overflows by Electricity. (Weil), ...	330
Public Civil Works, Reorganization of, ...	161
Works, National, ...	157, 244
Pure Water System, Hyatt, Report of the Committee on Science and the Arts, on, .	71
Purification of Mercury. (Crafts), ...	416
Quercitrin and Rutin, Supposed Identity of. (Schunk), ...	262
Railroad Signal, The Dougherty, Report of the Committee on Science and the Arts, on, ...	335
Rails in Active Service, Protection of, from Rust. (Spring), ...	417
Reading Railroad Terminal, The, ...	496
Reorganization of Public Civil Works, ...	161
Reymond, DuBois. Photograph of the Eye by the Magnesium Flash Light, . . .	162
Richards, Mrs. R. H. Sanitary Science in the Home, ...	95
Rigollet and Gouy. An Electro-Chemical Actinometer, ...	416
Rolling Machine, Simonds'. Report of the Committee on Science and the Arts on, .	345
Metal, The Simonds, ...	I
Rust, Protection of Rails in Active Service from. (Spring), ...	417
Rutin and Quercitrin, Supposed Identity of. (Schunk), ...	262
Sabine Pass, Improvement of. (Turtle), ...	137, 246
Reply to Capt. Turtle's Communication on. (Haupt), ...	140
Saccharin, Commercial, Detection of, in Food. (Bornstein), ...	416
Sanitary Science in the Home. (Richards), ...	95
Scaffold System, Trestle and, Ziegler's, Report of the Committee on Science and the Arts, on, ...	149
Schunk, E. The Supposed Identity of Rutin and Quercitrin, ...	262
Silicon, Preparing, A New Method of. (Warren), ...	498
Simonds, Geo. F. Universal Metal Rolling Machine, ...	I, 345
"Sludge" Acid, Petroleum, Utilization of. (Thompson), ...	260
Smith's and Windmill Islands, Philadelphia, Removal of, ...	339
Spring, W. Cause of Metallic Lustre, ...	419
Protection from Rust of Railroad Rails in Active Service, ...	417
Standard Measures. (Gieseler), ...	115
Steam, Efficiency of, at High Pressures. (Beauman), ...	495
Stieglitz, A. Insoluble Gelatine Films as a Substitute for Glass in Photography, .	162
Sulphur, Recovery of, from Alkali Waste. (Chance), ...	261
Telegraph, Writing, The. (Gump), ...	297
Temperature, Definition of, Determination of, etc. (Pictet), ...	212
Thompson, W. P. Utilization of Petroleum "Sludge" Acid, ...	260
Thomson, Elihu. Electric Welding, ...	399
Thurston, Robert H. Distribution of Internal Friction of Engines, ...	370
Time, Electrical Distribution of. (Brown), ...	14

Trestle and Scaffold System, Zeigler's, Report of the Committee on Science and the Arts, on, ...	149
Trimble, H. Cutch and Gambier, ...	417
Turtle, Thomas. Improvement of Sabine Pass, ...	137, 246
Underground Railroads in Philadelphia, Feasibility of. (Haupt), ...	448
United States Geological Survey, A Broader Field for. (Frazer), ...	208
United States, Iron Ores of. (Birkinbine), ...	190
Valve Diagram, The Zeuner. (Gow), ...	255
Vibrating Engine. (Lidback), ...	337
Vorce, L. D. See Keep, W. J., ...	220
Walter, Thomas Ustick, Memoir of. (Mason, Jr.), ...	404
Warren, H. W. A New Method of Preparing Silicon, ...	498
Water Overflows, Protection of Buildings Against. (Weil), ...	330
Water, Pure, The Hyatt System of. Report of the Committee on Science and the Arts, on, ...	71
Watt's Electric Furnaces. (Houston), ...	215
Weather Review, North Pennsylvania State Weather Service. May to October, 1888. <i>Supplements</i> , August to December.	169
Weighing Machines. (Kent), ...	330
Weil, Leopold. Protection of Buildings against Water Overflows, by Electricity, ...	399
Welding, Electric. (Thomson), ...	471
(Woodbury), ...	420
Weldon-Pechiney Process for the Manufacture of Chlorine, The. (Dewar), ...	64
Werdermann's Electric Furnaces. (Houston), ...	53, 232, 317
Werner, E. A. General Theory of Jointed Bow Girders, ...	339
Windmill and Smith's Islands, Philadelphia, Removal of, ...	471
Woodbury, C. J. H. Electric Welding, ...	297
Writing Telegraph, The. (Gump), ...	483
Zentmayer, Joseph, Memoir of, ...	255
Zeuner Valve Diagram, The. (Gow), ...	149
Ziegler's Patent Trestle and Scaffold System, Report of the Committee on Science and the Arts, on, ...	

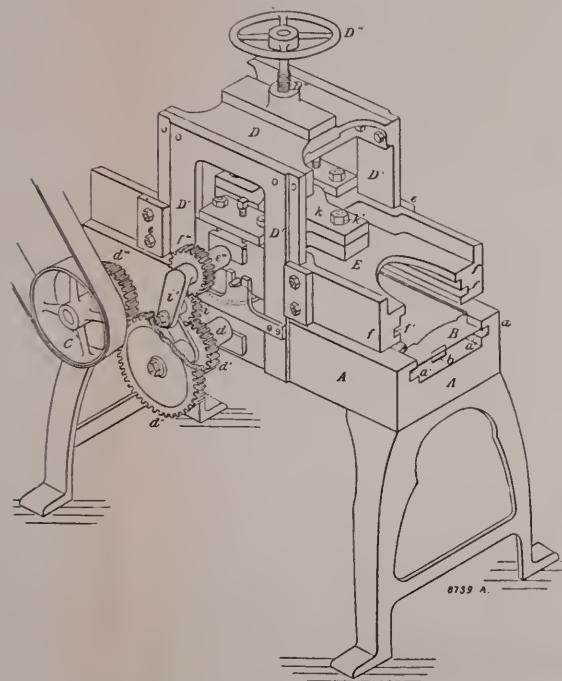


FIG. 8.

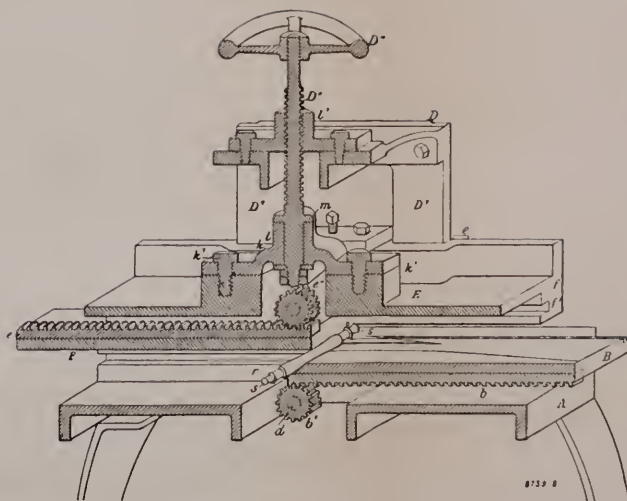


FIG. 9.

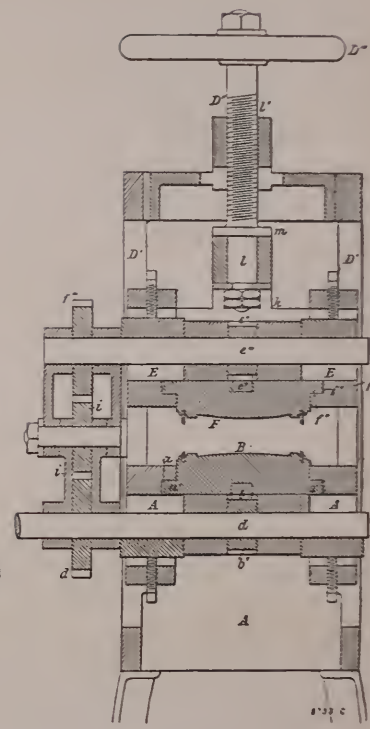


FIG. 10.

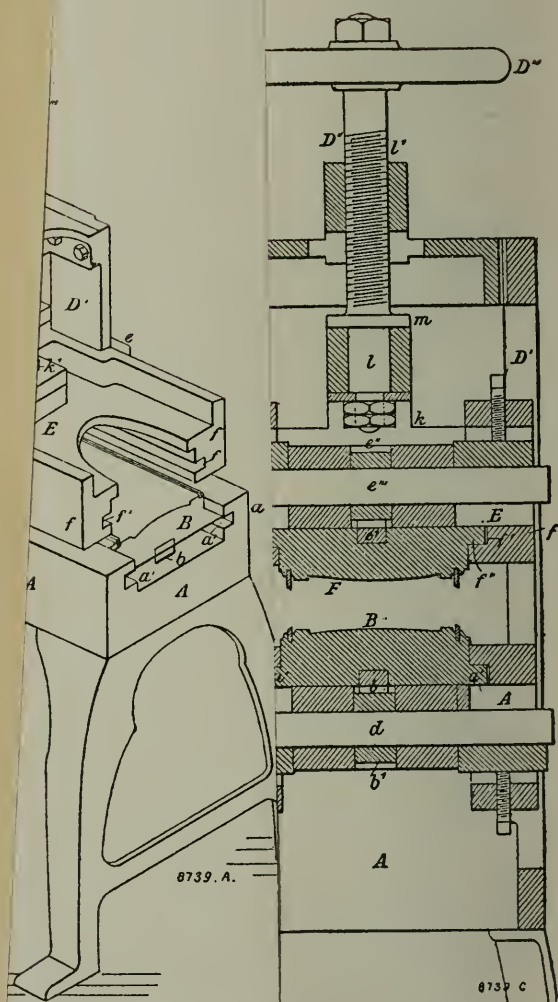


FIG. 10.

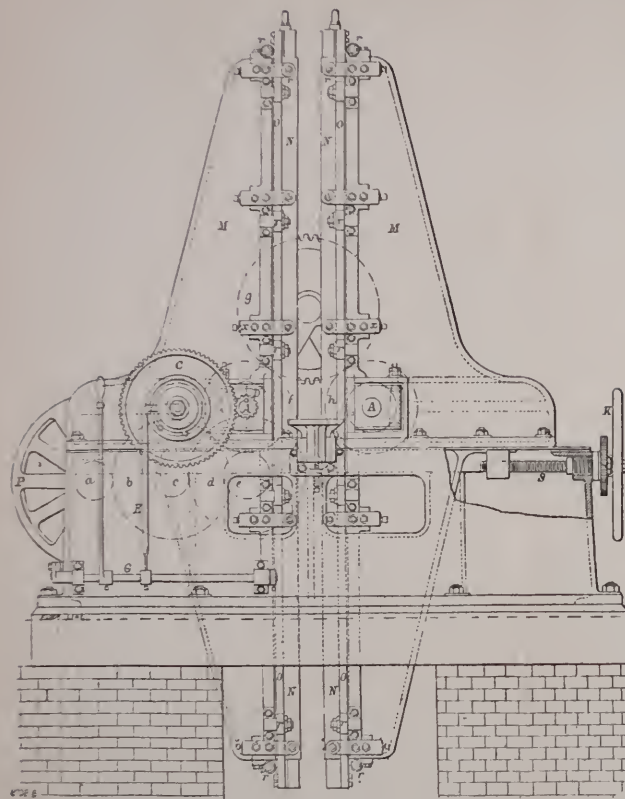


FIG. 12.

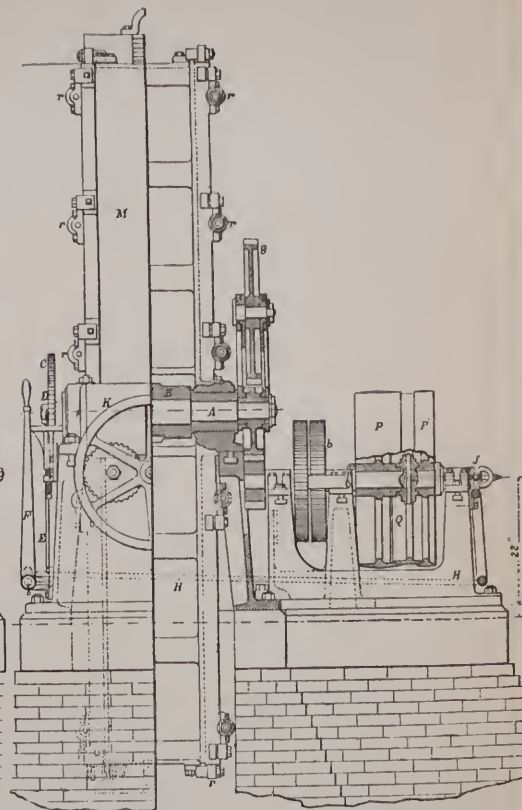


FIG. 13.

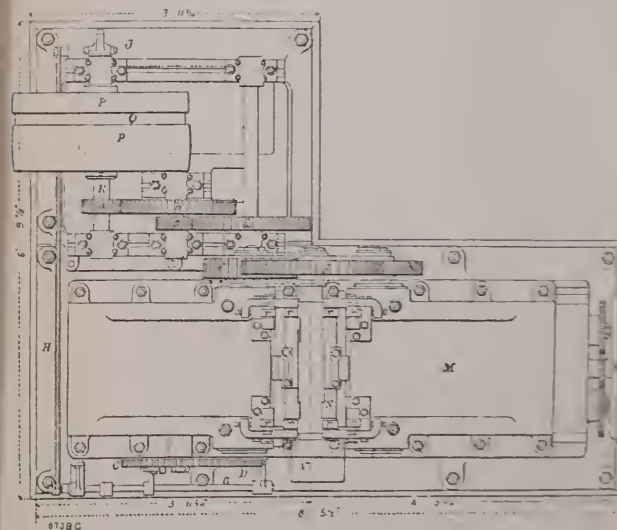


FIG. 14.

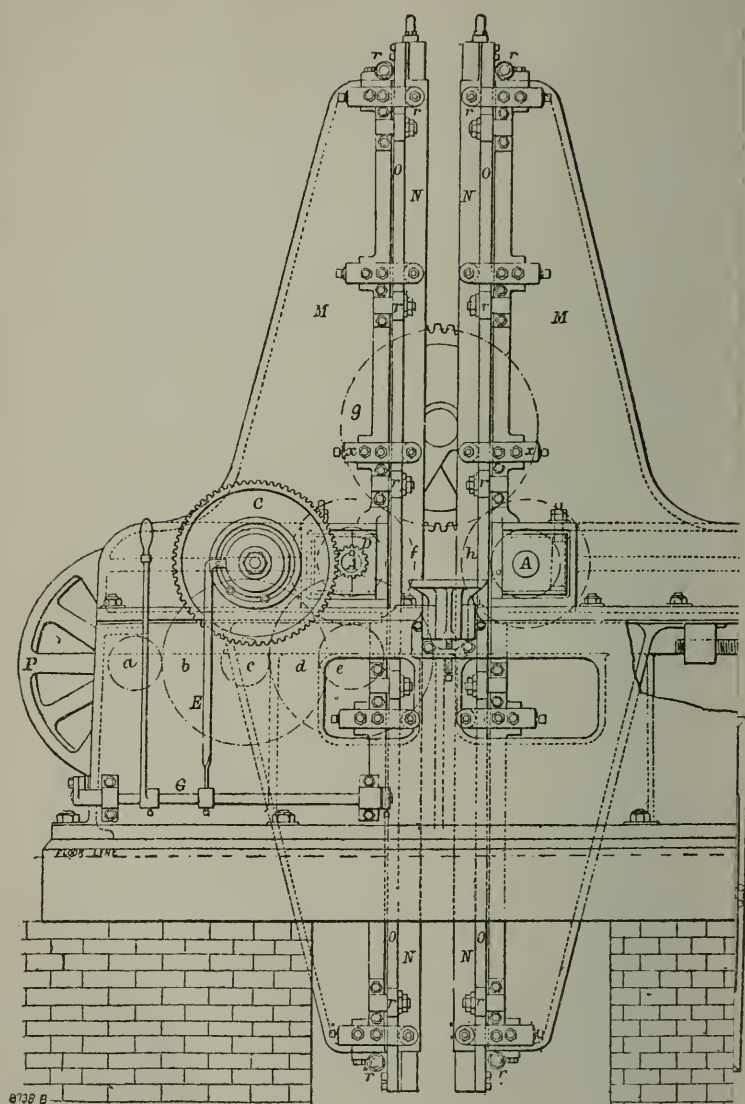


FIG. 12.

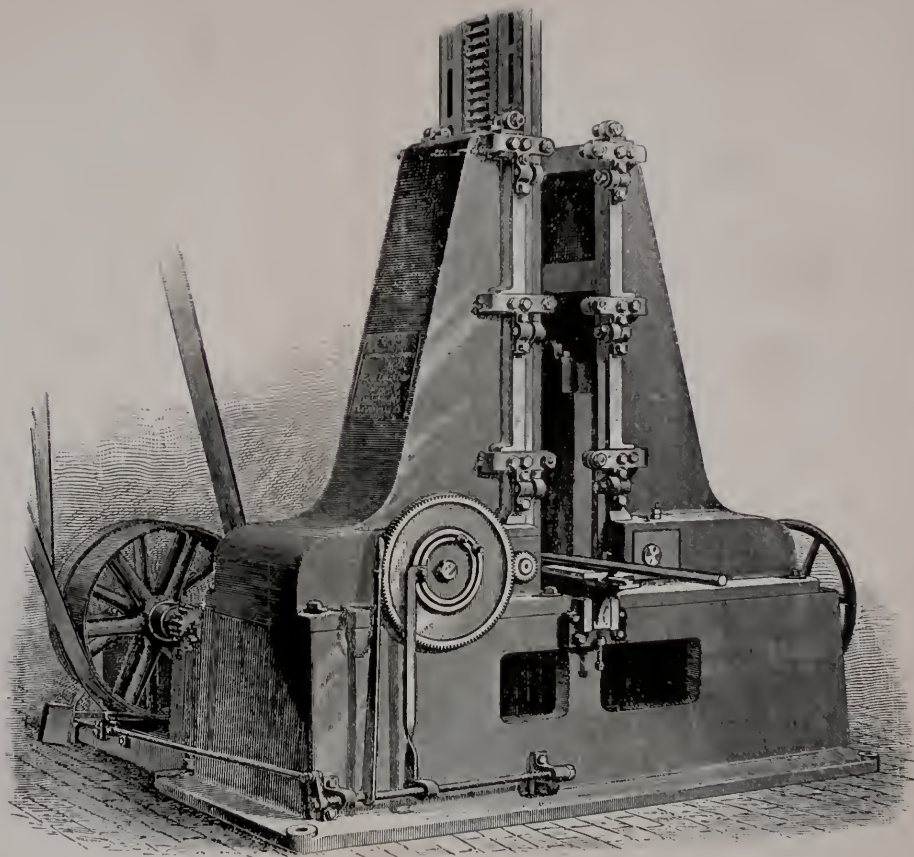
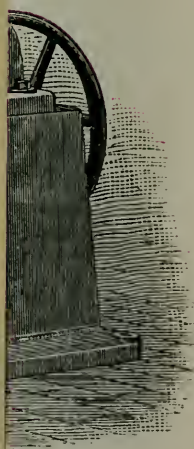


FIG. 11.



JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI.

JULY, 1888.

No. 1.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

THE SIMONDS' UNIVERSAL METAL ROLLING MACHINE.

BY GEORGE F. SIMONDS, Fitchburg, Mass.

[*Read at the Stated Meeting of the FRANKLIN INSTITUTE, Wednesday, June 20th, 1888.*]

JOS. M. WILSON, President, in the chair.

MR. PRESIDENT, MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The invention which I have the honor to explain to you, is the result of incident, of mistake, of reasoning, of experimenting. From a small germ, it has shown a steady and substantial growth. Difficulties have been encountered, but almost invariably the removal of a difficulty has developed some new and unexpected advantage. It has spread out and covered fields, broader than we dreamed of two years ago, until there seems to be no limit to its capabilities. It is the natural way to make an endless variety of articles, in the saving of manual toil, in the improving

WHOLE NO. VOL. CXXVI.—(THIRD SERIES, VOL. xcvi.)

of the quality of the articles produced, and in opening new opportunities for the employment and convenience of mankind. That it has reached perfection in all its details is not claimed. Far from it! for the possibilities of an invention covering so much ground could hardly be exhausted in the short space of four years, but the underlying principles are established, and it can safely be declared a success.

In January, 1884, while journeying from home, my attention was incidentally called to the possibility of forging round metal articles, like articles ordinarily made in a turning lathe, between oppositely moving surfaces. As has always been my custom when a new idea presented itself, I made a sketch of a device for practically carrying it into effect, and wrote a description of the same. On my return an experiment was made with putty as a material between two tapering shingles, grooved to form a ball, and with sufficient success to convince me that it could be developed to substantial results.

I wrote to my solicitor in Washington, explaining and describing what had been done, and asked him to make an examination in the Patent Office and report to me what had previously been attempted in that line. In due time he reported that he had made a careful preliminary examination of the records of the Patent Office, that there was nothing there of the character referred to, and that I had the field to myself. I was much surprised at this report, as it seemed very strange that so simple a principle had not been tried before, but, acting under the information received, I built a machine.

I had in my employ a young and intelligent mechanical engineer who made my drawings, superintended the construction of the machine, and tested it. After some weeks of persistent experimenting he reported to me, that, in his opinion, the thing was a failure and we must give it up. I told him to cover up the machine, and we would let it rest. Up to this time my dies had been constructed on inclined planes, approaching each other as the dies were moved forward, like the illustrations shown in *Figs. 1 and 2*. After a few days, I told him to make the drawings and construct dies to make a miniature car axle, in which the forming or shaping surfaces of the two dies should run parallel to each other, and the reducing and spreading surfaces diagonal to the

forming surfaces, and also at an angle to said forming surfaces and to each other, and said reducing and spreading surfaces to be provided with corrugations to force and control the rotation of

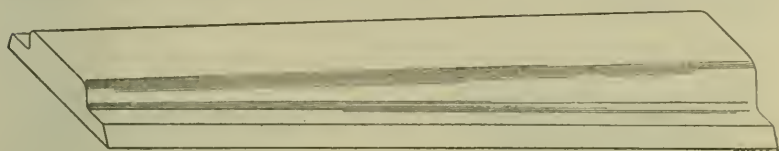


FIG. 1.

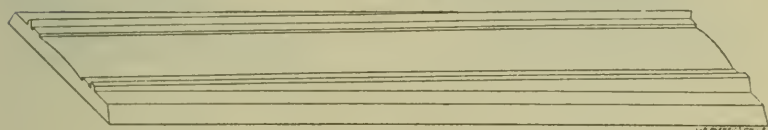


FIG. 2.

the blank being worked upon. These dies are illustrated, as shown in *Figs. 3, 4, 5, 6, 7*, and this was the germ from which the success of the invention developed. In addition to the small

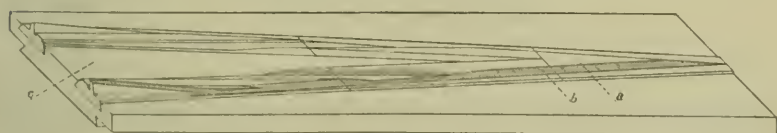


FIG. 3.

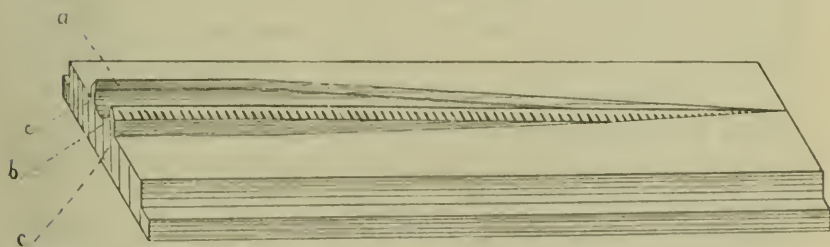


FIG. 4.

miniature car axles, which were then produced, I made dies for rolling balls and small projectiles, and applied for patents.

In June, 1884, I learned that the Patent Office work was much in arrears and that my application would get no hearing for six

months in the regular course. Through the courtesy of the Secretary of War, on account of the adaptability of the machine for war purposes, my cases were made "Special" and got immediate hearing. Much to my surprise I was confronted with a

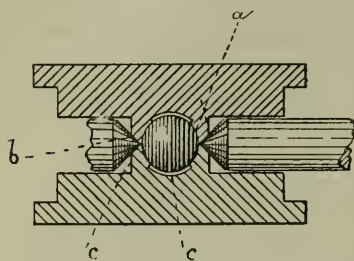


FIG. 5.

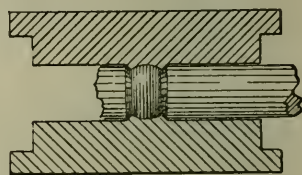


FIG. 6.

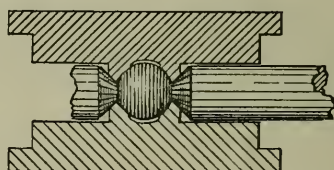


FIG. 7.

multitude of patents, and learned that many before me had attempted to accomplish results in the same direction, but so far as I could judge no machine was then in successful operation. I returned to my home from Washington, somewhat demoralized however, and uncertain as to the fate of my experimental investment. I would say here, that, except for this mistake on the part of my Washington solicitor, this invention would never have been developed by me, for, had he reported the facts as they existed, my original machine would not have been built.

For nearly a year the machine remained covered up, during which time it became apparent that no other person had ever accomplished what I had done, and after a personal investigation in many places in this and other countries, with the best of counsel, and with all the reference patents that could be found before us, we set to work to ascertain what I had done that they had not, that I should have gotten a result which they did not

attain. As a result of that investigation, my patents of June 9th, 1885, were issued to me.

Up to the time of the issuing of my original patents, I had made but one experimental machine. I immediately constructed what is termed a horizontal 6-inch and a 12-inch machine, and in November of the same year took two 6-inch machines and one 12-inch machine to London, England, set them in operation, secured an order from the English Government for a half million of Nordenfelt steel projectiles, and in February returned to America, having formed a company which owns the patents and is operating the machines in that and other European countries. The facilities and force of workmen in Fitchburg were at once increased, and developments continued in various directions until November, 1886, at which time a company was formed in the City of Boston, and substantial developing works were erected in the City of Fitchburg. In the summer of 1886 machines were made with dies running vertically with a marked success over the horizontal form of construction, and all machines for practical working are at present built on that principle.

(Illustrations of the first original machine, and of the machine of latest design were here shown on the screen.)

It is a somewhat remarkable fact, that among all those who had applied for patents on devices of this character, the man who came nearest success previous to the construction of this machine, made his experiments more than eighty years before mine commenced. So far as the records show, he made no attempt to roll anything but lead, and this only into balls, which is the simplest form on which the machine operates. But, with the softest of metals and on the simplest of forms, his dies were a failure.

The hardest metal, when heated, will yield and shape itself to your will with perfect ease, if you handle it right, but attempt to force it too rapidly, or against itself, and the result is a total failure. Dies that were made previous to mine, were so constructed as to attempt to force the metal into shape by direct pressure toward the axis of the bar. Again, no attempt was made to control the rotation of the blank to the required velocity, or to prevent the twisting of the blank or article between the dies, conditions absolutely essential to a successful prosecution of the work: to express it differently, the method of manufacture

under this principle was not discovered till my dies were originated.

If two platens with plane surfaces placed at a given distance apart, with their surfaces parallel, are moved in opposite directions, a round bar, with a diameter equal to the distance between the surfaces placed between them with its axis at right angles with the line of movement of the plates, will be rotated, without moving in the direction of either of the platens. If the diameters of the bar be somewhat greater than the distance between the platens, and if it be of plastic material, it is obvious that if it is introduced between the platens and rotated, its diameter must be reduced and its length increased. This is the fundamental conception which underlies what I have done and what others have attempted. If on the face of each of the platens, a narrow tapering rib be formed running in the direction of the line of motion, the rib of one platen being directly opposite that of the other, it can be easily seen that the movement of the platens will form a groove around the bar corresponding in cross-section with a cross-section of the ribs. It can also be seen that the metal at the bottom of the grooves formed by the ribs will be nearer the axis of the bar than the metal in contact with the plane surfaces of the platens. If the rate of rotation of the bar is determined by its contact with the surfaces of the platens, the rate of motion of the metal at the bottom of the grooves will be less than that of the surface of the ribs, and the ribs must slide over the surface of the bottom of the grooves. On the contrary, if the rate of rotation of the bar is determined by the contact of the metal at the bottom of the groove with the faces of the ribs, the metal in contact with the general surface of the platens will move faster than the dies. These facts present the first difficulties which arise in the attempt to make the fundamental idea available for practical purposes.

Again, it is easily seen that if two or more ribs are formed on each platen, their engagement with the metal of the bar will interfere with and restrain the axial elongation of the bar, which is indispensable to its reduction in diameter. This fact presents the second difficulty which is met and must be provided for, in forming round articles of varying diameters.

Again, if the rotation of the bar is secured only by the friction

of its working surface it is liable to fail, especially where the portions of the bar in contact with the dies are of different diameters. I think that all persons who, before myself, have endeavored to solve the problem of rolling round articles of varying diameters have failed to provide for these difficulties and conditions.

In my dies the portions which perform the work of shaping the article are raised above the general surface of the platens. These raised portions commence at a point and extend in two directions diagonally across the platen, or at an angle with its line of motion. The shaping of the bar commences at a point where the dies first come in contact with the bar, and proceeds spirally in both directions to the ends of the article.

The raised surface of the diverging ribs which form the die proper and which press directly toward the axis of the bar, or to the corresponding part of the opposite die, gives the required form to the article. I call this the forming or shaping surface (see letter *a*.) The outer surfaces of these ribs are formed at an angle of from ten to forty degrees with the axis of the bar, and by virtue of this inclined surface and of its diagonal position across the platen, an axial strain is brought upon the metal in contact with it, and the surplus metal is forced toward the ends of the article. I call this inclined surface the reducing and spreading surface (see letter *b*). This spreading surface is provided with teeth which engage with the metal and insure its rotation, and as the engagement is close to the portion of the rib or die which is acting on the metal, it gives the same rate of motion to the metal at that point that the die itself has. I thus ensure the efficient engagement of the metal with the die; the removal of the surplus metal axially; and the same rate of motion of the metal at the parts being acted upon, that the dies have.

It will be observed that these dies commence their operation by reducing the blank at any given desired point to the finished size of the article at that point, and spread the surplus metal axially, making and finishing the shape as the work progresses. The reducing and spreading surfaces remove the surplus metal outwardly, while the final finishing to accurate size and shape, and the obliterating of the marks caused by the rotating teeth is done on the forming or shaping surfaces near the junction of

those surfaces with the reducing and spreading surfaces. Or, in other words, the principal part of the work is done *outside* of the shape of the article and finished *inside* of the shape of the article. It will also be noticed that the rotation is forced and controlled outside of the shape of the article, or on the blank, instead of on the surface of the article. You will also see that by removing the surface of the die in places, or cutting it away where no work is being performed (see letter *c*), I take away all unnecessary friction between the blank or article and the dies, which leaves the rotating teeth free to force and control the rotation of the blank. By the construction of these teeth the velocity of the rotation of the blank at any given point may be increased or retarded when desirable. The fact that the rotation can be controlled on a given diameter makes the rolling of irregular shapes possible.

One of the earliest and most serious difficulties that presented itself in the practical working of the machine, was occasioned by the dies slipping on the blank that was being rolled. The first experimental dies were constructed of cast-iron, and the corrugations, or teeth, to control the rotation of the work, and prevent the slipping, were formed by cutting transverse grooves on the reducing and spreading surfaces with a round-nose chisel. On the first dies made of steel, the teeth were formed with a chisel, as a file cutter cuts a file. Later on, knurls were introduced for forming the teeth, which method is now employed, and which is entirely satisfactory. The dies, as you will observe by illustration in *Fig. 3*, are made on a cast-iron bed, planed to fit into the platens on the machine, and their faces are provided with dovetail diverging recesses, which receive and retain the steel working surfaces of the dies. These steel surfaces are made in sections, so that they may be hardened and tempered with facility, and nicely fitted to the bed. To give the proper form to the dies, a templet is made conforming to one-half a section of an article to be produced, and the forming and shaping surfaces on the dies, are then planed with that templet to conform to a section of one-half of the article. The dies are then placed diagonal to the bed of the planer, and, with a square-faced tool, the reducing and spreading surfaces are planed diagonal to the forming surfaces, commencing at the starting point on the die, and extending to the finishing end of the die. The question of angles is important in

the construction of these dies, the horizontal angles varying from 8 degrees to 20 degrees, and the vertical angles from 10 degrees to 45 degrees.

In the practical working of the machine, the bar from which the article is to be produced is heated at one end, the heated portion placed between the dies, and, as the dies move simultaneously in opposite directions, the bar is rotated on its axis between them, and the proper form or shape given to the article during one passage of the dies. The dies are then returned to position, and the operation repeated to make another article.

In the production of any article, other than a plain cylinder, as the dies must of necessity move with equal velocity, there must be a slipping of some part, or parts, of the article on the dies, or a twisting of the article, unless some provision is made to avoid it, and the twisting of the article is very objectionable, as will hereinafter be described. The system of cutting away the dies where the work is not being performed, to a great extent removes this difficulty, and this is an important feature in the successful working of this process. Other features have been introduced to avoid this trouble, which it is not necessary for me to herein enumerate. One of the difficulties encountered, and which at one time seemed serious, was a tendency of the work to come out of round and to show a seam, or a hole through the centre, or, as some would express it, become piped. Any one who has had an extended experience in working iron or steel under a trip-hammer, has encountered this difficulty with inferior qualities of steel and iron. I have discovered that one cause of this condition of things with this machine, is the twisting of the stock between the dies, and if the twisting is avoided the difficulty is largely avoided. Another cause is rolling the bar under pressure after the necessary work is done. If a round bar of iron or steel is rolled between two flat surfaces, with a gradual increased pressure, it will assume a three-cornered shape, or, in other words, more metal will rotate between two plates in a three-cornered than in a round form, and there will be a tendency to shatter the centre of the bar, and a slight seam, or hole, will appear, extending through that part of the bar so acted upon. I have recently made changes in the dies for preventing the articles coming out of round, which is effectual.

In the earlier experiments one uniform grade of high-priced steel was used, for the reason that there could be gotten in the market, any size of this steel and in any quantity, and an attempt to work different varieties of steel would introduce needless complications and delay. When the experiments were transferred to the low-priced, open-hearth, and Bessemer steel, this tendency of the work coming out of round, and with a hollow centre, was more apparent than with the crucible steel, but in the construction of the dies having avoided the difficulty of the work coming out of round, the soundness of the product depends, as in other methods of forging, on the strength and homogeneousness of the steel. We are buying in the open market open-hearth steel, not made expressly for us, from which we are producing a great variety of articles that are without exception satisfactory to purchasers and users, in fact, I think, in every instance, since the correct principle of the construction of the dies was discovered, every article produced has been pronounced superior to those made by the old processes.

From the samples which you see before you, you will notice that we have succeeded in rolling many kinds of irregular shapes like ovals, squares, hexagons, pinions, etc. You will also observe that articles have been threaded with satisfactory results, and during the same operation in which the blank is rolled to shape. In fact, all the underlying principles necessary to a complete success of the process have been fully established, and the problems before us relate principally to the production of accurate and uniform work. By the present methods in the manufacture of many of the articles which this machine produces, after the article is forged to approximate shape and size, the surplus metal is necessarily cut away, to bring it to the finish size, by means of cutting tools. The lack of uniformity by those methods is largely due to the give or spring of the machine, and the wear of the tools in use. By this present method the machine can be constructed with great rigidity, and there is no perceptible wear on the dies to change the form or size of the work. During the past year we have rolled 8,000,000 boot calks, the little pointed tool steel articles, which you see on the case before you. Our dies have not been worked under as good and favorable conditions as we can even now use them, but we can roll, as an aver-

age, 100,000 forgings without removing the dies from the machine, while the surface of the dies is not then materially worn away. After rolling, as an average 100,000 forgings, we find it desirable to renew the rotating teeth, and to do this we anneal the steel portion of the dies, plane their surfaces, taking off a slight chip, temper them, and they are again ready for use. In this way, with one set of steels in a die, we have rolled 600,000 forgings. The dies will invariably produce a reverse *fac simile* of themselves, and under the right conditions the articles will be exact duplicates of each other. Those conditions consist simply in a uniform metal that is being worked, and a uniform heating of that metal. We have reason to believe that we can bring those conditions within such narrow limits as to compete in uniformity in the manufacture of such articles as the machine will produce, with the results as now attained by existing methods. One of the advantages of this system of manufacturing is, we can use steel of high or medium temper, as well as the softest steel or iron. In consequence of this we start with a material that is stronger than is now generally used. Again, it is a well-established fact that a forged steel article which retains the skin surface has a greater tensile strength, will stand a heavier breaking weight, possesses superior wearing qualities, and when used as a projectile will endure a more powerful impact strain to what it does when that surface is removed. These two facts insure a great advantage in the quality of goods produced.

Experiments have demonstrated that we can roll from the square, hexagon, or octagon bar with equal facility as from the round bar; this enables us to roll from what is known among metal workers as the billet, and produce any shape, round, square, hexagon, oval, tapering, threaded, or otherwise, introducing all the various shapes into the same die and with a uniform result; in this way the whole system under which a great variety of goods are produced can be changed to advantage. Many articles are at present made from a finished bar smaller than some portion of the article, and the larger portion is formed by upsetting; this has a tendency to shatter the fibre of the metal and otherwise weaken it by forming cold shuts. We start from a billet larger than the largest portion of the article to be produced, and shape the whole at one operation; or, in other words, avoid the neces-

sity of using a finished bar from which to make our product, thus saving the expense of one operation in the manufacture of the raw material.

An important advantage by this method of forging is the saving in the power required over the use of hammers, drops, or hydraulic presses. The work is done principally on inclined planes, and there is a continuous and substantially a uniform amount of work from the time the operation is commenced until it is finished, and under the most favorable conditions as regards power, and wear and tear of machines.

Several tests of the quality of the products of the machines have been made, and I will cite two as illustration: The Nordenfelt projectile ordered by the English government are three inches long by one inch in diameter. They were required to vary not over one thirty-second of an inch in length, and less than five one-thousandth in diameter from a given size at three points, and also to be to an exact taper; the machine rolled them within these limitations. Ten shots were fired by the English officers at the testing grounds at Woolrich in the presence of Commander Folger, of the U. S. Navy, and myself. The range was one hundred yards, and they were fired through a one-half inch steel armor plate and against a like plate placed fifteen inches in the rear of, and at an angle of forty-five degrees to the first plate. After this remarkably severe experience they were so little distorted as to stand the gauge tests. The officers in charge pronounced them the best shot that ever went through their guns. The Government was at that time manufacturing these projectiles at Woolwich, they discontinued the manufacture and gave the order referred to.

In April last past, and within a week after the first die was made to roll a fish-bar bolt, ten bolts were submitted to and tested by the Pennsylvania Railroad Company in comparison with five of their standard bolts as now in use. They were pronounced satisfactory in workmanship, and stood a tensile strain of an average of thirty per cent. more than the standard.

Previous to the construction of this machine, hardened steel balls, accurate to size, were unknown. To-day we are furnishing them in any quantity and of any size up to two inches in diameter, that vary less than one-thousandth of an inch in size, and

can manufacture to six inches or even larger if required. The Lick telescope revolves on hardened steel balls one inch in diameter, rolled with this machine. Balls two inches in diameter of great accuracy and precision have been supplied to a famous scientist with which he accomplishes results heretofore impossible.

Four propositions seem to have been fully established pertaining to this invention :

First : Any article that comes within the range of the machine can be made at a less cost than as now produced.

Second : Everything that the machine makes can be turned out superior in quality to the same article as now manufactured.

Third : Experiments have demonstrated that large articles are rolled with the same facility as those that are small in size.

Fourth : There is no conceivable limit to the variety of work that it is capable of producing.

As a comprehensive illustration of the possibilities of this process I may mention, that a coach axle can be rolled from the billet, complete at one pass of the dies, giving all the forms and shapes required, viz.: round, hexagon, square, the collars, the journals, the threads for the nuts, and cut to length, and in less than thirty seconds of time.

[Referring to the illustrations, Plates I., II., and III., Fig. 8 is an illustration of the first machine made with the dies arranged to move horizontally. Fig. 9 is a front sectional view of the same, showing dies for rolling a small car axle; and Fig. 10 an end vertical section. Fig. 11 is a general view of the machine, of a later design, with the dies in a vertical position; while Fig. 12 gives a front elevation of the same. Fig. 13 an end view and vertical section, and Fig. 14 a plan view.]

THE ELECTRICAL DISTRIBUTION OF TIME.

By ALLAN D. BROWN, Commander, U. S. Navy, Assistant Superintendent of the Naval Observatory, Washington.

[*A Lecture delivered before the FRANKLIN INSTITUTE, January, 13, 1888.*]

Concluded from Vol. CXXV., page 474.

From the General Post-Office the time is distributed in the city of London hourly and throughout the country at 10 A. M. and 1 P. M.; the arrangement for this distribution is very elaborate, there being four groups of circuits, each worked by a separate relay, which is itself worked by the hourly signal from the observatory. The lines within the city being used for time purposes only are always in circuit; the country lines, however, are used for ordinary commercial purposes; hence it is necessary that they should be cut out just before the times at which the signal is to be transmitted; this is accomplished automatically by a specially-constructed clock which opens the relays about two minutes before the hours of 10 and 1, thus clearing the lines for the reception of the signal; about ten seconds after its passage the relays are closed by the action of the clock. It will be observed that the signal sent over the wires is but a single beat, and is, therefore, of a character that would hardly be suitable for use in this country of magnificent distances. All of the time service work outside the observatory (except that of the Deal ball) is under the supervision of the Post-Office Department, and a large number of persons are thus supplied with the Greenwich time direct; in many cases the signal is repeated by local operators to smaller offices, so that, practically speaking, the standard time of the country is dispersed throughout England, Scotland and Wales; in Ireland, Dublin time is the standard, and Greenwich time is used only for purposes of comparison.

In addition to the time ball at Deal, a like ball is dropped daily at the same hour (1 P. M.) from one of the turrets of the observatory; this ball is the oldest in existence, having been first dropped

in 1833. Time guns are fired by the same signal at Newcastle and North Shields.

Reference has been made to the distribution of time by private parties in the city of London; this is done by the firm of Barraud and Lund, whose system is one of much ingenuity. In it ordinary clocks are provided with an attachment by which the error of the clock can be corrected at any exact hour, provided that this error does not exceed two minutes. In the central office is a mean time regulator provided with means for correction of its error by an electrical attachment similar to that in use at the observatory in Greenwich; the error of the standard is ascertained by a comparison of the signal received from the observatory at each hour, with the beats of the regulator which are registered upon a chronograph. The regulator is corrected when necessary and sends automatically a signal over all the lines leading from the office at 0 minutes and 0 seconds of each hour. This signal actuates the armature of an electro-magnet in each clock; from this armature are projecting arms which make a sliding connection with the setting pins which protrude through a slot in the dial, and act like a thumb and finger to bring the minute hand to the 0 position; the arms have a counterpoise which serves to bring them back to their normal position when the current ceases; the contact in the regulator clock is not instantaneous, but prolonged for some seconds in order to be sure of effecting the desired correction. Combined with these synchronizing clocks are audible and visual signals, the first being made by a bell, the second by a revolving disc which shows alternately red and white; such a signal is used in the London Stock Exchange; but it would seem to have the disadvantage of requiring that attention should be directed to it for some time before its arrival.

In Liverpool, Glasgow and Edinburgh the Greenwich time is distributed by several clocks provided with the Jones system of regulation; at least this was the case up to a comparatively recent date.

In Paris, the observatory distributes the time to thirteen so-called horary centres, each of which is furnished with a secondary clock that is in itself a good and expensive timekeeper, and is regulated by the central clock through a modification of the Jones system. The central standard, besides being provided with the most approved

compensation, has also upon the pendulum a small box in which light weights are from time to time placed or from which they are removed to restore the rate of the clock to the normal when it is found to have been disturbed. At each vibration of the pendulum the circuit is closed for a large fraction of a second and the current from the battery switched in; this animates an electro-magnet situated beneath the centre of the arc of vibration, so that a piece of soft iron carried by the pendulum bob is attracted, and thus the clock (which is kept running on a gaining rate) is retarded; the adjustment is made so that the amount of retardation is just sufficient to keep the secondary clocks beating in unison with the primary. The secondary clocks send hourly signals automatically to various places in their immediate vicinity, thus distributing the time over a large area. I am informed, however, by a gentleman who has recently been in Paris and examined the subject, that this system is one that is not now depended on.

In various cities of the continent the system of Hipp is used quite extensively; in this system a central- or master-clock drives a number of secondary ones, very much after the system used at Greenwich. In Berlin there are a few clocks regulated on the Jones system, but there cannot be said to be what is regarded as an efficient time service.

Some idea of the extent of the distribution of time from observatories in this country may be gathered from the statement that there are over 124,000 miles of railway thus supplied; of this number, the Naval Observatory at Washington supplies 29,000 miles; that at Allegheny, Pa., 24,000 miles; that of the Washington University at St. Louis, Mo., 22,000 miles; being a total of 75,000 miles; the remaining 49,000 are supplied by nineteen other observatories, two of which are in Canada.

The system used by all, except the Naval Observatory, is what may be called a continuous one; that is to say, the standard mean time clock records its beats—with certain omissions—upon various sounders connected with it. In some of these clocks the contact wheel on the seconds arbor is so cut as to send the signal every second, omitting certain seconds at the close of the minute, the beat following this pause marking the beginning of each successive minute; in others, only the even seconds are transmitted, with a similar arrangement for determining the beginning of each minute;

some have every fifth minute noted by an omission of a different character, and in others a like omission marks the termination of the hour. It is evident that there is no way in which to mark any particular minute; in the fifth minute system the time can be identified by a distant receiver, provided he knows what fifth minute is being signalled—in other words, if he is sure of his time within two and one-half minutes; in the hourly system there will be evidently no trouble in recognizing the hour at its termination. As a rule, these observatories are connected by wire with the establishments of various jewelers and watchmakers in the immediate vicinity, as well as with the telegraph wires leading out of the city. At a certain prescribed hour—generally just before noon—the operator in the telegraph office switches his wires into connection with those from the observatory, and the beats of the standard clock are thus transmitted over a greater or less extent of country; the time thus received is used primarily by the railways, and secondarily by the jewelers and others in the towns through which the lines pass; in some instances these have sounders in their own offices; this is especially the case in the larger cities. In smaller towns, the signal is taken off the sounder in the office by comparison with a watch, which is itself afterward used as a means of comparing the regulator and thus ascertaining the error of the latter.

Generally speaking, the time received by the railways is only at their division headquarters, and later it is transmitted over each division wire by hand, the clock in the office being taken as the standard. The uniform train rules of the railroads now prescribe that the hours for the distribution of time shall be 5 P. M. Eastern time, or 4 P. M. Central time.

The system adopted by the Naval Observatory at Washington is like that at Greenwich, in that signals are sent only at a certain prescribed time, viz., at noon of the seventy-fifth meridian. The practice at Greenwich of altering the standard clock, and sending its beats over the wires, is not, however, that used in Washington; there the standard clock is allowed to run on and accumulate its error without interference, a separate clock, called the transmitter, being used for the purpose of sending the time signals. This clock is compared at 11.40 A. M. daily with the standard, which has itself been compared with the standard sidereal clock at 9

A. M., as well on the evening before, if observations have been made. If an inspection of the barometric and thermometric records shows no large fluctuations, it is assumed that the rate of the clocks has been constant; if such changes are noticed, however, allowance is made for them by the observer, in accordance with his judgment, derived from previous experience. This is, in effect, the same thing as is done at those observatories where the standard clock is used, only there this clock is altered by the use of weights upon the pendulum, while with us the error of the transmitter is ascertained, and then the latter is set to the correct time. Being thus set as nearly as possible—and this can be done to within the twentieth of a second by means of the chronograph—at three and one-fourth minutes before noon the clock is switched into the circuits leading from the observatory to the offices of the Western Union Telegraph Company, the Signal Service and the Fire Alarm; the seconds transmitting wheel is so cut as to omit the twenty-ninth second, as also the last five seconds of each minute; an additional wheel is placed on the seconds arbor, having a peculiar shaped tooth which comes into play in the sixtieth second of each minute when the proper switch is turned; as the beats progress an observer at a distant station notices the omission of a single beat; by this he knows at once that it is the half minute signal; as some time must necessarily elapse before the signals reach stations so distant as Boston or New Orleans, it follows that all the signals will not be heard at all stations; hence it becomes necessary for the operator to take up the count at thirty, and keep it up until fifty is reached; if more ticks are heard he is made aware that there is at least one more minute to come; should, however, the ticks cease at fifty, he knows that it is the last minute of the hour, and that the next signal will be that made by the transmitting clock as its seconds hand reaches the exact instant of noon. The sender at the clock at that time (ten seconds before twelve) switches out the seconds beat and switches in the minute one; as the seconds hand comes to sixty, the tooth before spoken of causes the current to pass, not merely for a fraction of a second, but for the whole of that time, thus not only distinguishing it from all other signals sent, but also ensuring sufficient time for full contact of the armatures of all relays, time-ball magnets, etc., reached by it.

In connection with the observatory, reached over the wires of the Western Union Telegraph Company, are time balls at Wood's Holl, Mass., Newport, R. I., New York City, Philadelphia, Baltimore, Hampton Roads, Savannah and New Orleans. A ball is also dropped on the Navy Department building in Washington, being connected with the observatory by a special wire.

The connections from the clock are briefly as shown in the diagram on the board: A two pt. repeater of peculiar construction is placed on top of the clock case, the circuit through the coils of its magnets and the points of the transmitting springs being normally closed; as the wheel already described revolves, these points are slightly separated; the circuit is broken and the armature released, the opposite end being drawn down by the tension of a spring, making a circuit through one of the posts upon which the lever strikes and an eight pt. repeater upon a table near by; this in turn makes a circuit through the eight wires leading from it when the proper switches are turned; the other post of the two pt. repeater is used only for dropping the time ball above referred to. The action of this repeater is peculiar, inasmuch as by it the seconds beat, instead of being of but an instant's duration, lasts about one-tenth second, a great advantage in the long distances over which the signal passes. The signal sent to the fire-alarm office sets in motion an automatic apparatus, by means of which all the fire bells in the city are made to strike the hour, the first stroke being very nearly the instant of noon by the clock; of course, some allowance must be made for the action of the striking mechanism, but for all practical purposes the time thus given may be said to be exact. A like signal is sent at 7 A. M. and 6 P. M., and the bells struck at those hours.

The observatory has also in times past used the Jones system for the control of distant clocks with a very considerable degree of success, but as has been the case at Greenwich, experience has led to the abandonment of all attempts at any service outside the observatory, which require the continuous use of a wire and in which the clocks depend for their correctness upon the constant transmission of signals. As I have before said, the Jones system requires that the secondary clocks should be quite as good time-keepers as the primary, which is in itself a grave objection on account of the expense involved. If from any cause there is a fault

on the line (and I need not say that such faults are too apt to occur), the secondaries go on running each with its own error, so that when the line is repaired, the connections again restored, and the current passes, it is not only improbable that all the clocks will show the same minute and second, but in the highest degree probable that they will not do so.

As in these remarks I have assumed that an astronomical observatory must be the base from which time is to be distributed electrically, but little has been said concerning the various systems of so-called electric time which are now so much in vogue. So far as I am aware, no proposal has yet been made to use the clocks of any of these systems in other than detached groups, each having its own master or driving clock, which is not in connection with any source from whence correct standard time is derived; each master clock runs on at its own rate so that no two of half a dozen groups will show the correct time. However practicable it might be to have such a system in a single town or a number of such in a large city, it is quite evident that on the score of expense alone it would be impossible for the observatory at Allegheny or Washington to be connected with such a system in this city; and hence the time furnished by it would not be reliable.

The idea of employing the electric current as a motor for clocks is one that is very entrancing, and that has been carried out with more or less success by the inventions of various persons; reference has already been made to the early system of Wheatstone, as also to that of Hipp, which latter is probably the one that is the most widely employed on the other side of the Atlantic, and to some small extent in this country. Probably most of you are familiar with the system in use in some of the stations of the Pennsylvania Railroad, and if so, you are likewise familiar with the fact that not infrequently one or more of the dials is covered with paper to prevent its incorrect indications from misleading the public. That some of the dials should go wrong is almost inevitable, even where the lines are confined to a single building; and it may be added here that at Greenwich, where there is a similar system used, it has been found necessary to provide other clocks of the ordinary pattern, furnished with the necessary contact arrangements, for use in case of the failure of those operated by electricity. As the published reports of the observatory state that these extra ones are

occasionally used, it is fair to presume that the others have not been found exempt from the failures to which all such arrangements are liable. I think that it may be safely said that experience has developed these facts: (1) that no machinery which depends upon a current derived from a battery for its motive-power is reliable; (2) that no step-by-step apparatus can be depended upon always to perform its functions; (3) that nothing is more certain than that the wires connecting any series of buildings or towns will at some time get out of order. From these facts it can readily be deduced that electro-motor clocks are not to be relied on, except within a very limited sphere, and then only with the most constant and unremitting attention to all parts of the apparatus and connections.

There are undoubtedly some of these clocks that are better than others; one of the latest is that of Speller of this city; it would seem that in this plan a good many of the mechanical and electrical difficulties which surround the problem have been attacked with a reasonable degree of success; but you will observe in the specimen which is here shown, first, that the master clock is not of a first-class character, being very likely to be affected in its rate by all sorts of influences, and further that it is not in connection with any source whence the standard time is derived. It is true that the time can be obtained from the telegraph office as it is sent from Washington, and the clock then set to correspond; but that is a method which requires too much time and attention; secondly, you will notice that the secondary clock moves but once a minute; that is to say, that it is correct just once in sixty seconds (when I say, correct I mean in accord with the master clock), so that it is impossible to tell what time it is to within nearly a minute; for instance when the hands of the secondary point to five minutes past nine, the other clock may be at five minutes and fifty-nine seconds past; this may be considered sufficiently correct, but if a man was in haste to catch a train he might be easily deceived by thinking that he had nearly a minute more than was really the case. The seconds hand has evidently been abandoned by the inventor of this system, as there is much less expenditure of battery power and certain mechanical difficulties are avoided. There are electrical difficulties also in the way of running a very large number of these clocks on one circuit.

For the reasons that have been cited above, the idea of sympathetic, has been abandoned by those experienced in their workings, for that of synchronized, clocks. The system of Barraud and Lund, in use in London, has already been described. Even that, however, is hardly applicable to our own country, where it is not always possible to receive even a daily signal, for in London it has been found best to correct these clocks hourly.

It may be assumed as the result of many years' experience, (1) that electricity is the most suitable power for controlling clocks at a distance from a central standard, since it is the only available force which acts with sufficient quickness to avoid delay and ensure accuracy; (2) that it must be used as a setting or controlling, and not as a motive-power, inasmuch as sooner or later failures in the connections or breaks in the wires stop the clocks, and hence cause confusion to all who look to them for time; (3) that the cost of maintenance must be reduced to the lowest point, and for this purpose the wires must be in use as short a time as possible, and the least amount of force necessary to set the clocks right must be applied to the secondaries; this also involves the reduction of the amount of attention necessary to be paid to each clock to the lowest possible point; (4) that the system must be such that clocks of differing patterns can readily be included in the circuit, and that the correcting mechanism can easily be applied to them. The system used in London fulfils these functions quite well within its limits; but it has its disadvantages in that its power of correction is limited to the minute hand only, and that for an error not exceeding two minutes. This system has been used at the Naval Observatory at Washington (as have others also), but none have been found to fully cover the requirements of the case until the adoption of the one now in use; this is the Gardner system, by which the correction is made to both seconds, minute and hour hands, and in which there is no limit to the number of minutes that can be corrected, an error of twenty-five minutes being overcome as easily as one of twenty-five seconds!

The clock shown here, is one such as we use in the observatory and on our clock line running to the various public buildings. One of the points of the 8 pt. repeater mentioned above, is connected with this line; where in air it is an insulated wire; elsewhere it is in the Waring cable. There are over eight miles in the

circuit, and upon it more than 350 clocks. In each building entered by the line there is, of course, a local circuit, upon which as large a number of clocks as 100 are worked. There is no complaint as to the working of the system. During the three and a half years that it has been in operation all our trouble has been upon the line; the clocks themselves and the correcting apparatus give us no anxiety. Now, it is quite plain that these line troubles would have caused a system of sympathetic clocks to have ceased operations entirely, while in this plan the clocks have gone on running, and as soon as the line has been repaired, by the simple turning of the proper switches the clocks have been corrected to coincide with the observatory standard. The Pension Office has seventy-five of these clocks, and quite recently the Patent Office (abandoning all others) has put in some 140. There are clocks of this pattern also in use at Newport, Hampton Roads and Savannah, giving, so far as I know, perfect satisfaction, and wherever the observatory signal goes they can be used.

I had finished writing the foregoing remarks and felt that I appreciated, to some degree at least, the necessity that exists for exactness of time, when this cutting from the *New York World* of January 1st, was handed me. I will not weary you by reading it at length; suffice it to say that it discloses a most lamentable state of affairs existing in the public clocks of the great metropolis. The writer states that there is just one place where accurate time can be obtained; and that is from the time ball on the Western Union building, to see which drop hundreds of people assemble on every week day, hardly appreciating, probably, that the signal which drops the ball comes from the Observatory clock, over 200 miles away. When, however, one goes up Broadway and attempts to compare his watch with the various clocks that are to be seen he will have, as the reporter says, "an interesting time." No two of them are alike; and often the different faces of the same clock are discordant. Even the clocks in front of the great jewelry establishments are rarely correct, though they are very imposing, in more senses than one. Here are some illustrations of the way in which New Yorkers are treated in this matter. The clock at the corner of Broadway and Twenty-first Street at noon showed twenty-five minutes past one! The one on the next block was a little nearer correct, showing but four minutes after twelve. The worst

specimen of all was the one in the Fifth Avenue Hotel, which, at high noon, informed the guests of that establishment that the hour was twenty-five minutes past ten ! Well may it be said that reform in this matter is imperatively necessary !

Now that we have the system of standard time in use, an observatory must necessarily be the source of this time, and it becomes more than ever important that communication with well-established institutions of this sort should be regular and constant. There should be no such state of affairs as has been shown to exist in New York, nor is there any necessity therefor. The observatory at Washington was established on account of the needs of the navy for an accurate standard of time, and following the example of other Government institutions, it naturally gives to commerce its assistance when needed. The time balls already alluded to are but the beginning of what it is hoped will be a comprehensive system embracing the whole coast, so that in every commercial city there shall be a like installation. All that is wanted is an appropriation of the money that has been asked for, and which it is to be hoped will be granted. Nor is this the only function of the observatory, as has been shown already in the statement of the extent to which its time signals are distributed. Its system is the result of much study and experiment, and is believed to be fully suited to the needs of the community which it can serve, scattered as it is over such wide extent of country, and necessitating such long-distance transmission of the signals.

IS ENGINEERING ON THE DECLINE?

BY WILLIAM BARNET LEVAN.

[*Read at the Stated Meeting of the FRANKLIN INSTITUTE, Wednesday,
April 18, 1888.*]

There is probably no profession which is so little understood by the general public as that of engineering. The question of sound and advanced engineering is one that greatly affects a community whose prosperity depends mainly on the efforts of practical science. Ability and integrity are indispensable qualifications in those who are entrusted with the expenditure of large sums of money in works of public utility. A great work that involves immense original outlay and large yearly expense of maintenance, may be made one per cent. more profitable by the best engineer than by the second best; and out of this one per cent. a liberal amount may well be paid the former for his superior abilities. Therefore, all that the best men have done in the past should be known and compared with our present practice, to prevent us from beginning behind the age and help us to make further progress.

The object of my paper to-night is to call the attention of the public at large to the system in which the construction of our railroads and other incorporated companies are now projected and carried out. It is evident that the first and principal object in most of these works is, that they shall be made productive to those through whose instrumentality the legislative powers are obtained, with but a remote regard to the interests of those who may ultimately become the proprietors of shares, or to the benefit or convenience of the public.

IS ENGINEERING ON THE DECLINE?

The writer is not willing to assert or admit that such is the case, and many grand triumphs of modern engineers might be cited to prove that there has been no decadence in engineering skill.

But the writer does assert that many important public and private enterprises which might be made commercially profitable to investors in them, and of great advantage to the public and to all parties concerned, are handicapped at their outset by reason of the

fact that the engineering departments are entrusted to unskilled and incompetent hands; and the truth of such assertion finds conspicuous illustration in several enterprises of a public and private character that are being conducted, and are in progress in our midst.

This may appear to be a somewhat broad assertion, but it is, nevertheless, one amply justified by the facts which are open to the consideration of all who choose to seek for them.

Let any fair and impartial first-class engineer examine and report upon our public works and those of incorporated companies, and in a majority of cases the verdict in a condensed form will be that they are extravagantly arranged, located and operated.

MECHANICAL ENGINEERING.

What is wanted is economical power; the fact is that but very few manufacturers who use steam power, and especially those controlled by incorporated companies, are aware to what extent the economy of a mill or works, run by any given engine and boilers, is affected by circumstances under which it is located and erected to produce the best results as to wear and tear as well as fuel consumption.

Very many persons—and persons, too, who ought to know better—imagine that a steam engine which is good for one situation is good for all, whereas a greater error than such an assumption can scarcely be imagined. It is true that there are certain makes of engines which may be relied upon to give moderately good results in almost any situation; but not when the *best* results are desired—and the best results always *should* be desired in any manufacturing establishment.

The selection of an engine for the performance of any given work, due regard being of course paid to the nature of the work to be performed, also, how far it is advisable to divide the total power required amongst a number of engines for the purpose of saving shafting and for general convenience, is of itself a most important one, and demands independent consideration.

The next point to be decided is, whether a condensing or a non-condensing engine is to be employed. Except under conditions in which the exhaust steam from a non-condensing engine can be turned to good account for heating purposes, it may safely be

asserted that in all instances where a sufficient supply of condensing water is available at a moderate cost, the extra economy of a well-constructed compound condensing engine will fully warrant the additional cost involved, especially if the power exceeds 100 horse-power.

Boilers are an important factor in the production of economical power. The importance of the use of *high pressure steam* cannot be too constantly urged upon engineers and manufacturers, and that the employment of low pressure steam to run engines is extremely wasteful; yet clear as this is or should be to all intelligent engineers and steam users, they do not recognize its truth. To illustrate! When using steam at forty pounds above atmospheric pressure in a non-condensing engine, one-third of the whole of the power is consumed in overcoming the atmospheric pressure; while if steam were used at 100 pounds to the square inch, one and one-tenth of the power would be so wasted, due to the pressure of the atmosphere (14.7 pounds) being a greater percentage if a low pressure is used than in the case of a high pressure.

It has been proven, both in practice and theory, that the greater the difference between the steam pressure on the piston and the resisting force of the condenser or atmosphere, the higher will be the mechanical efficacy of the steam, hence the necessity of employing high pressure steam in order to obtain the fullest effect of expansion.

It is a well-known fact that the secret of economy in running steam engines lies in the adoption of the highest practicable pressure of steam, thorough jacketing, the earliest cut-off at which the engine will run, and as perfect condensation of steam as possible after the steam has done that work.

No engine can run economically at a high grade of expansion except it be fitted with a condenser; for the greatest economy of expansive working lies in expanding below the pressure of the atmosphere.

Having decided on your motive-power, a location for your works should be in order; in Philadelphia a large river front is presented, and, therefore, in this city there should be no difficulty on this point.

The most important items of expense in any large establishment run by steam power are the *fuel* and *water*, especially in cities where the latter is charged by the cubic foot.

There is an old saying, "That the best is not good enough." It may be assumed as a fact that a steam engine employed for driving a mill or works of any kind cannot be too good, the saving effected by the economical running of the best engines in the great majority of cases enormously outweighing the interest on their extra first cost. So few persons appear to have a clear idea of the vast importance of economy of fuel in large works, that I cannot better illustrate than by showing the saving that can be made in large establishments by the use of the most modern economical make of engines.

COMPARISONS.

(1) We will take the Brush Electric Light Company, Johnson Street, west of Twentieth Street and south of Market Street, this being a modern plant with ample capital behind it.

As regards the location of these works for supplying arc lights, for all intents and purposes they could just as well have been located on the Schuylkill River, where more ground could have been obtained for the amount paid for the present location, besides the advantages of *free water* and cheaper fuel, as the latter could have been set down in their works by boat or rail, thus saving extra handling and cartage.

MOTIVE-POWER.

The present plant consists of ten non-condensing automatic cut-off engines, to wit :

Eight Porter-Allen engines of forty horse-power each, of the following dimensions :

Diameter of cylinder in inches, ...	8
Length of stroke in inches, ...	16
Revolutions per minute, ...	290

Two Corliss engines, connected at right angles to the main-shaft, of the following dimensions :

Diameter of cylinder in inches, ...	23
Length of stroke in feet, ...	4
Revolutions per minute, ...	75
Boiler pressure in pounds per square inch above atmosphere, .	105

These two engines are capable of developing each 250 horse-power with ease, and in case of an emergency 800 horse-power could be realized.

The eight Porter-Allen engines are only run between 5 and 10 P.M., when the demand for light is the greatest.

The average horse-power developed during the twenty-four hours will be about 400, and as the Corliss engines are kept continuously running, we will base their cost for fuel on these data.

The following indicator diagram (*Fig. 1*) from a non condensing Corliss engine, is a fair sample of the distribution of steam in the cylinder.

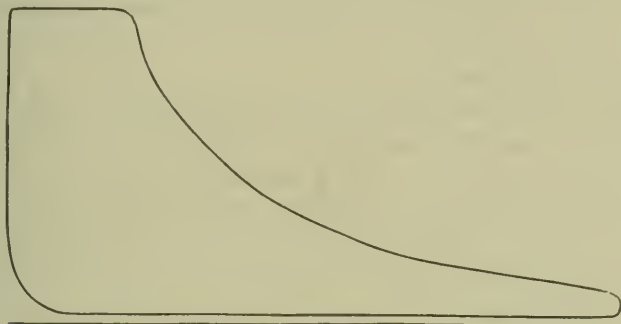


FIG. 1.

Diameter of cylinder in inches, ...	22
Length of stroke in inches, ...	48
Revolutions per minute, ...	78
Boiler pressure in pounds per square inch, ...	60
Coal per hour per horse-power in pounds, ...	3

BOILERS.

The boilers are sixteen in number, consisting of four Babcock & Wilcox Company make, and rated by them at 300 horse-power, based on 11 square feet of heating surface per horse-power and 108 square feet of grate surface.

There are also six horizontal flue boilers, 40 inches in diameter and 17 feet long, containing nineteen flues of 4 inches diameter and 115 square feet of grate surface.

There are also six horizontal flue boilers, 42 inches in diameter and 20 feet long, containing nineteen flues of 4 inches diameter and also 115 square feet of grate surface. The steam pressure carried averages about 105 pounds above the atmosphere and according to calorimetric test averages about three per cent. of water.

FEED WATER.

The charge for feed water for boilers in Philadelphia is based on the maximum horse-power developed, and the rate is \$3 per horse-power per annum; therefore, the water rent for this works will be as follows:

$$400 \times 3 = 1,200 \text{ dollars per year.}$$

COAL CONSUMED.

The consumption of coal can be very nearly arrived at by the type of engine. Corliss non-condensing engines as generally run will average a consumption of coal of *three and one-half pounds per hour per horse-power*.

Taking into consideration the high steam pressure used in this establishment, and the fact that the engines are run to their full capacity only a portion of the twenty-four hours, and that the small engines are not as economical as large ones, and that the eight Porter-Allen engines are used during the demand for the most light, the above-stated consumption per hour per horse-power will be a fair basis to estimate the coal burnt in these works during the twenty-four hours run.

The coal used must be hauled in carts, say one-half mile, and taking into consideration the good quality of coal employed, \$4 will be a fair price per ton delivered. The cost of fuel will be as follows:

$$\begin{array}{rcl} \text{Horse-power, } 400 \times 3.5 & = & 1,400 \text{ pounds per hour.} \\ 1,400 \times 24 & = & 33,600 \text{ pounds per day.} \\ 33,600 \times 365 & = & 12,264,000 \text{ pounds per year.} \\ 12,264,000 \div 2,000 & = & 6,132 \text{ tons per year.} \\ 6,132 \times 4 & = & 24,528 \text{ dollars per year.} \end{array}$$

PROPER LOCATION OF WORKS.

Now, had these works been placed on the river front, as they should have been at the time of their erection, more ground could have been had for the outlay made for their present location, with the advantages of *free boiler feed water*, and coal at a less price per ton delivered direct in the works by rail or boat.

And another, a very important advantage, to wit: in the place of using non-condensing engines, compound condensing engines could have been employed with but a slight advance above the present cost of plant.

A good condenser will increase the economical power of an engine from *twenty* to *forty per cent.*, or for the same power effect a corresponding saving in the amount of steam used and fuel consumed.

Therefore, in plain terms, if *three pounds* of coal be necessary per hour per horse-power, with a well proportioned and erected non-condensing engine, then *two and one-half pounds* of coal will develop the same power with a first-class condensing engine, as will be shown by the following indicator diagram from a Corliss condensing engine.

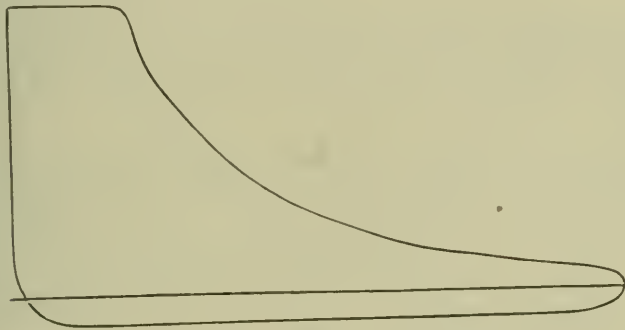


FIG. 2.

Diameter of cylinder in inches, ...	20
Length of stroke in inches, ...	48
Revolutions per minute, ...	61
Piston speed in feet, ...	488
Pressure of steam per square inch in pounds, ...	89
Vacuum per gauge in inches, ...	27
Indicated horse-power, ...	220
Coal per indicated horse-power per hour in pounds, ...	2'295

ADVANTAGES OF THE COMPOUND STEAM ENGINE.

- (1) It furnishes a better working engine, mechanically, for utilizing the benefits of the expansion of high-pressure steam.
- (2) Independently of mechanical consideration, it is more economical to use steam expansively in a compound engine than in any form of the ordinary engine.

COMPOUND CONDENSING ENGINES.

The following diagram was taken from a compound condensing Corliss engine. The mill was originally driven by a pair of horizontal slide valve engines, with cut-off of the following dimensions:

Diameter of cylinders in inches, ...	24
Length of stroke in feet, ...	4

In order to get good results, it was arranged to erect boilers adapted to carry at least 160 pounds steam per square inch, and to replace one of the twenty-four inch slide valve cylinders by a Corliss cylinder fourteen inches in diameter and four feet stroke, the new cylinder was steam jacketed, and the cranks being at right angles a receiver was placed between the engines.

This alteration has been found to be a very great improvement, and the following diagrams (*Figs. 3 and 4*) taken from the altered engines, speak for themselves.

FIG. 3.

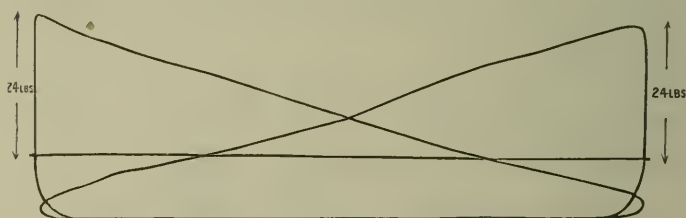
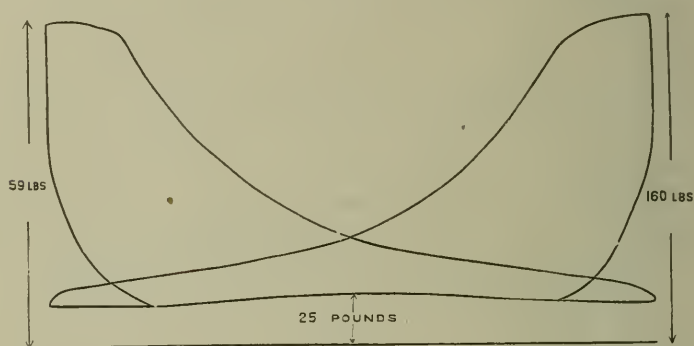


FIG. 4.

It will be seen that running sixty revolutions per minute, and with 165 pounds of steam in the boiler, the non-condensing Corliss cylinder indicates 125.2 horse-power, with a mean pressure of fifty-six pounds, and the condensing cylinder 131.1 horse-power, with a mean pressure of 19.75 pounds, or, collectively, 256.3 horse-power. About one pound of difference of pressure is shown between the two cylinders.

This engine has been frequently run up to 350 horse-power, when all the mill machinery has been on at once. The con-

sumption of water so stated has been measured, and found to be about thirteen pounds per hour, per indicated horse-power, equivalent to a consumption of 1.3 pounds of coal per hour per indicated horse-power, with a boiler evaporation of ten pounds of water per pound of coal. The steam was very dry and the indicator cards account for but 10.33 pounds of water per hour per horse-power developed.

Had the Brush Electric Light Company, therefore, been located at the river and fitted up to run compound condensing in the place of non-condensing engines, the cost per annum would have been :

(1) Water from river free.

(2) Coal at a reduced price owing to there being no cartage, which, including the extra handling, would amount to, say, fifty cents per ton, making the cost delivered \$3.50 in place of \$4 per ton.

Assuming that the steam pressure would be the same as now carried, namely, 105 pounds per square inch above the atmosphere, under any circumstances, the power could be produced for *two pounds of coal per hour per horse-power.*

Then

400 ×	2 =	800 pounds per hour.
800 ×	24 =	19,200 pounds per day.
19,200 ×	365 =	7,008,000 pounds per year.
7,008,000 ÷	2,000 =	3,504 tons per year.
3,504 ×	3.50 =	12,262 dollars per year.

Thus the saving, if located on river front fitted with compound condensing engines as compared with the present location with non-condensing engines, would be as follows:

Cost at present location for water, ...	\$1,200 00
Cost at present location for coal, ...	24,528 00
Total cost, ...	<u>\$25,728 00</u>
Cost if located at river, ...	12,262 00
Saving per year, ...	<u>\$13,466 00</u>

In fact it would pay this company at the present time to excavate on their present premises to the depth of fifteen or twenty feet, place new compound condensing engines in said excavations and make a connection to the river Schuylkill by a line of pipe for their condensation water. This could easily be done as the curb

line on Johnson Street is but thirty three feet above low-water mark. If they excavated twenty feet the water would only have to be lifted about, say, eighteen feet at low water.

I make this statement based on the increasing business of the company. I also understand it is their intention to add 500 additional horse-power in the near future.

The next case of any magnitude is the plant of the Philadelphia Traction Company, located on Market Street below Twentieth Street, as to which, so far as the work to be performed is concerned, location would be immaterial.

MOTIVE POWER.

The steam engines are of the same make and about the same horse-power, namely, two non-condensing Corliss engines, with the exception that they are separate in place of being coupled to one shaft, and the power is transmitted by gearing in place of a belt, as in the case of the Brush Electric Light Company; in all other respects they are substantially the same, and are rated also at 250 horse-power each. The dimensions are as follows:

Diameter of cylinder in inches, ...	24
Length of stroke in inches, ...	48
Revolutions per minute, ...	65
Boiler pressure above atmosphere in pounds, ...	90

BOILERS.

The boilers are six in number and are commonly called "Two-story" boilers. The lower horizontal shell is 14 feet in length and 4 feet in diameter, the upper horizontal shell is 15 1/2 feet long and 4 feet in diameter, and the two are connected by four necks, 14 inches diameter, about 12 inches long; the lower shell contains forty flues, four inches in diameter.

This style of boiler is not as economical as those of the Brush Electric Light Company, and will consume more coal per hour per horse-power.

The engines in this works, considering the type of boiler and the slow piston speed, will require about four pounds of coal per hour per horse-power.

The average run per day will be about twenty-two hours, and develop in round numbers, say, 400 horse-power. The cost of coal delivered per ton will average about \$3.75.

Then we have cost of fuel and water, as follows :

Water rent at \$3 per horse-power per annum,

$$400 \times 3 = 1,200 \text{ dollars.}$$

Coal at the rate of \$3.75 per ton.

$$400 \times 4 = 1,600 \text{ pounds per hour.}$$

$$1,600 \times 22 = 35,200 \text{ pounds per day.}$$

$$35,200 \times 365 = 12,848,000 \text{ pounds per year.}$$

$$12,848,000 \div 2,000 = 6,424 \text{ tons per year.}$$

$$6,424 \times 3.75 = 24,090 \text{ dollars per year.}$$

Had this plant been located at the river front, and been fitted with compound condensing engines, the cost per year would have been as follows :

$$400 \times 2 = 800 \text{ pounds per hour.}$$

$$800 \times 22 = 17,600 \text{ pounds per day.}$$

$$17,600 \times 365 = 6,424,000 \text{ pounds per year.}$$

$$6,424,000 \div 2,000 = 3,212 \text{ tons per year.}$$

$$3,212 \times 3.75 = 12,045 \text{ dollars per year.}$$

Water rent free from river.

Then the saving would have been, if located at the river front, and by the use of compound condensing engines, as follows :

Cost per annum at present location :

Water rent per year, ... \$1,200 00

Coal per year, ... 24,090 00

\$25,290 00

Cost at river front, ... 12,045 00

A saving per year of \$13,245 00

I will next refer to the proposed Edison electric lighting plant on Sansom Street above Ninth, Philadelphia, as described in *Philadelphia Press* on March 4, 1888, as follows :

"The building will have a front of seventy feet on Sansom Street, and will extend 100 feet back toward Walnut Street. Its cornice will tower 114 feet above the pavement, overshadowing all the lofty roofs in the neighborhood.

"Twenty engines, of 250 horse-power each, will be placed on the first floor. Forty dynamos, with a capacity of 1,500 lights each, or a total capacity of 60,000 lights, will rest on the second floor. On the floor above the dynamos will be the workshops, where wire and conduits are prepared for laying in the streets and

making connections with houses. Clear up on the fourth floor huge boilers, with a capacity of 5,000 horse-power, will be placed. In the fifth floor will be stored over 1,000 tons of coal at a time. The sixth floor, where light and air will abound, as its windows will look twenty feet above the roof of the Continental Hotel, will contain the general offices of the company and space for its clerical force.

FOUNDATIONS ENORMOUS AND SOLID.

"This sounds like an amazing way of erecting a plant, with huge boilers and tons of coal in the air, but this reversal of the ordinary arrangement of machinery is due to the necessity of concentrating enormous power within a limited space. It also necessitates construction of the most massive kind. In the first place, the whole lot will be covered with a deep bed of concrete, four feet in vertical thickness. Resting on this bed will be the foundation walls, five feet thick. The twenty engines on the first floor, which will each hum at the rate of 200 revolutions a minute, are of the high-speed Armington & Sims type. They will each be firmly planted on a concrete monolith fifteen feet square. These twenty monoliths will rest upon a bed of sand one foot thick which in turn rests upon the bed of concrete four feet thick. The dynamos on the floor above the engines will weigh seven tons each and will make 650 revolutions a minute. They will rest on heavy iron beams supported by iron pillars, each pillar being capable of upholding 500 tons. Other pillars and beams support the floors above the boilers, furnaces and coal. The coal is to be driven upon scales, weighed and dropped into a pit. Chutes will be so arranged that the coal can be readily loaded on elevators and carried to the fifth floor. There the coal will be dropped into bins, from which a pipe runs at an inclination to the furnace of each boiler. All this machinery for delivering and feeding the fuel under the boiler will be strongly but simply designed to save time and handling.

FUEL AND BLASTS FOR THE FURNACES.

"On the third floor there will be placed two blast fans, capable of driving 50,000 cubic feet of air per minute into the furnaces. The smoke and other products of combustion will be carried from the furnaces into two chimneys of nine feet internal diameter.

These chimneys or smoke stacks make an original detail of the building, for they will appear as bay windows, starting at the third floor and reaching to the roof. These apparent bay windows will be at the rear of the building; the bay windows shown in the front elevation will contain spiral staircases. There will also be a passenger elevator in the front portion of the structure.

"Pipes will carry the steam from the boilers to the engines on the first floor, and a huge exhaust pipe will rise from the engines to the top of the building. This exhaust pipe will be four feet in diameter at its top, and probably there is no exhaust pipe in use in Philadelphia as large as this.

HOW THE CURRENT IS DISTRIBUTED.

"Every known scientific appliance will be used to regulate the distribution of electricity and to secure perfect uniformity and regularity in the brilliancy of the lamps. Edison's skill in this direction is pre-eminent, and his inventions will be utilized in every possible way. There will be thirty-five great feeding mains running from the station. Each feeding main consists of three bars of copper as thick as a man's thumb. To each of these mains a regulating apparatus is specially attached, so that the pressure is constantly kept at exactly the same point, whether one lamp or 1,000 may be burning on a main. In other words, this regulating apparatus keeps the quantity of current supplied to a main exactly proportioned to the demand.

"When this great station on Sansom Street is completed, it will cost the company about \$1,000,000. It will be one of the sights of the city, and will dwarf the wonders of the electrical exhibition four years ago, which brought thousands of visitors to Philadelphia. But as it will be, this plant is only the beginning of the plan of the company. It will supply only the central portions of the city, and it is expected that other stations nearly, if not quite as large, will be erected in Kensington, Richmond, Spring Garden, Northern Liberties, Germantown, Southwark, West Philadelphia and elsewhere. Already the company has expended \$250,000 in copper conductors, eleven miles of which are laid under Chestnut and Walnut Streets, between Twentieth and Fourth Streets. During the coming summer twenty miles more of conductors are to be laid, extending between the Delaware and

the Schuylkill, under Market Street from the Delaware to the Public Buildings, and on intersecting streets connecting with Spruce, Pine and South Streets."

MOTIVE-POWER.

In regard to the *Armington & Sims* engines, I have no indicator diagrams to refer to, except such as are illustrated in their circulars of date about 1885; their engine was entered for competition at the International Electrical Exhibition of the *FRANKLIN INSTITUTE* in 1884, but was withdrawn before the tests of engine were made.

The following diagram, *Fig. 5*, was taken from one of their engines, 12 x 12 inches, running 350 revolutions per minute,

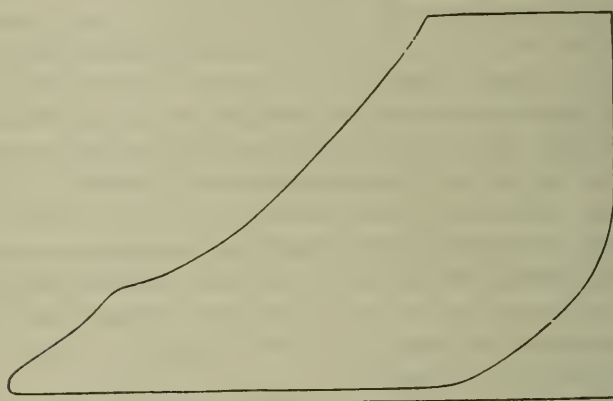


FIG. 5.

coupled direct to one of *Edison's* large dynamos; mean effective pressure on piston, 45.28 pounds; indicated horse-power, 106.6.

The following diagram, *Fig. 6*, was taken in September, 1883, by *Prof. Thurston*, who examined, by request, the design, construction and workmanship, to observe their power of automatic regulation, and to determine what power was demanded in operating electric lights.

The engine was 9½ x 12 inches, running 280 revolutions per minute. Water consumption per hour per horse-power, when fifty lights were on, was, according to the cards, 21.5 pounds. *Thomson-Houston* dynamos of twenty-five lights each.

This engine, as will be seen from the indicator diagrams, is of

the single valve type, the valve being hollow piston valve, and therefore cannot be as economical as the before described engines.

On page 9 of their circular it is stated: "The engines are adapted to work under the highest pressure, if required. By the



FIG. 6.

use of suitable condensing apparatus, the power of these engines can be increased twenty-five per cent."

The following diagram, *Fig. 7*, is from an *Armington & Sims* condensing engine, built in 1886, of dimensions as below:

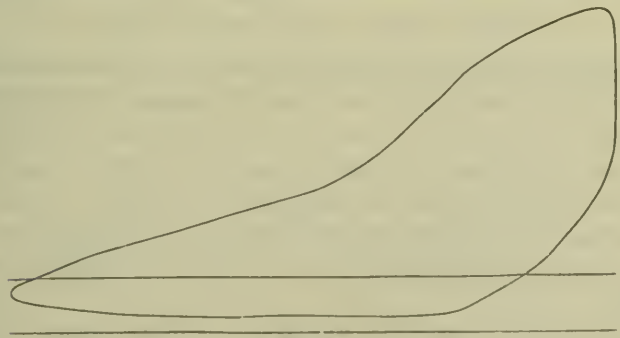


FIG. 7 *

Diameter of cylinder in inches, ...	18'5
Stroke in inches, ...	30'
Revolutions per minute, ...	120'
Boiler pressure per pound, ...	70'
Vacuum in inches, ...	25'5

* The sizes of the foregoing diagrams have been made to conform to the pages of the JOURNAL.

The construction of boilers to be used is not mentioned, but I understand they are to be of the water-tube type, and to have a forced blast.

The number of lights of this system to the horse-power, average ten of sixteen candle-power per lamp; consequently, to run 50,000 lights as above will require 5,000 horse-power, and no doubt in a short time, as stated in the quoted description, 6,000 horse-power will be required; therefore, we will be safe in basing an estimate on 3,000 horse-power for every twenty-four hours. And with the coal used in banking the fires when some of the engines are standing during the day, a fair basis for the coal consumption will be *four pounds of coal per hour per horse-power*.

Then we have water rent as follows:

$$3,000 \times 3 = 9,000 \text{ dollars.}$$

Amount of coal consumed, as follows:

$$\begin{array}{rcl} 3,000 \times 4 & = & 12,000 \text{ pounds per hour.} \\ 12,000 \times 24 & = & 288,000 \text{ pounds per day.} \\ 288,000 \times 365 & = & 105,120,000 \text{ pounds per year.} \\ 105,120,000 \div 2,000 & = & 52,560 \text{ tons per year.} \\ 52,560 \times 4.50 & = & 236,520 \text{ dollars per year.} \end{array}$$

EDISON'S DIRECT LOW-TENSION SYSTEM.

From the published account, as quoted, it will be seen that this is a very large undertaking, not from the number of lights, 60,000 in number, but under nearly all electric-light systems, especially in those like Mr. Edison's, in which currents of great quantity and low electro-motive force are employed, very large copper conductors have to be employed, by which the great outgoing current of electricity is distributed over a district to be lighted from the station.

The system is termed the "three-wire" direct system, and is of peculiar and of interesting construction.

My object in giving the above description is to show that on account of the low electro-motive force, expensive conductors as above described have to be used, and as a means of saving first outlay the works containing the motive power and dynamos are as a general thing placed as near the centre of the district to be lighted as is convenient.

Now I maintain that by locating the station at the river front the additional cost of increased size or number of conductors will be saved in the first year's run based on 50,000 lights.

Not being in the confidence of the Edison management, I am unable to state the cost per lineal foot of such conductors, including junction boxes and the laying of same, but am satisfied, from a personal examination of the conductors and boxes and the connections as are now in process of being laid on Sansom Street, that in addition to the \$250,000 already invested an additional \$125,000 would place the plant on the Schuylkill River front, say at Sansom Street, and would nearly pay the additional cost of same, in the first year's run.*

The distance from Ninth and Sansom Streets, according to the city plan, to the Schuylkill River is 7,600 feet. The greater portion of this distance is already provided for in the \$250,000.

Now let us see what the cost of power would be provided the location was on the river front. The cost, with additional property over that now proposed, would not exceed the cost of present location.

The cost of first-class compound condensing engines and steam generators would be the same as those contemplated, and the advantages would be as follows :

(1) Free water from the river.

(2) Cheap coal price delivered by rail or boat would not exceed at present time \$3.75 per ton.

Then we would have

$$\begin{aligned}
 3,000 \times 2 &= 6,000 \text{ pounds per hour.} \\
 6,000 \times 24 &= 144,000 \text{ pounds per day.} \\
 144,000 \times 365 &= 52,560,000 \text{ pounds per year.} \\
 52,560,000 \div 2,000 &= 26,280 \text{ tons per year.} \\
 26,280 \times 3.75 &= 98,550 \text{ dollars per year.}
 \end{aligned}$$

By changing the location, and using first-class engines and boilers, the saving will be as follows :

Cost at proposed location, water rent, ...	\$9,000
" " " coal, ...	236,520
	\$245,520
Cost at river front, ...	98,550
Saving per year, ...	\$146,970

* See note at close of paper.

L.

CIVIL ENGINEERING.

In building a railroad there is a peculiar condition relating to its economical running, in which it differs from the economical working of the ordinary manufacturer. A railroad must be as nearly straight as possible when it is first constructed, as improvements made afterwards cost double, as, for instance, the straightening of the New York Division of the Pennsylvania Railroad between this city and Jersey City, now under way.

A manufacturer of cotton or woollen goods, or of an electric light plant, may, at any time, add expensive and more economical machinery or buildings, and thereby produce a better or a cheaper article or light, but in building a railroad, especially if for a city terminus, this cannot be readily done. If the road bed is not originally well laid out and constructed, and capable of being run cheaply and safely, it can only be re-organized at a cost equalling that of a new line.

Let us take as an instance the proposed terminus of the Reading Railroad. This company is engaged at the present time in buying and securing expensive properties along the proposed route at extravagant prices, and when secured, an enormous outlay will be required to erect the superstructure of the proposed road-bed, as shown in the *Philadelphia Times* of March 22, 1888.

This plan will necessitate two reverse curves, which, at the high speed required on the proposed iron structure, will require a gang of boiler riveters constantly at work to make it stable for the service required, as is best illustrated on the elevated iron portion of the Pennsylvania Road at Twenty-second and Twenty-third Streets, where men are constantly employed redriving rivets in the structure; also on the elevated road in New York.

Every one knows that when the Tabor branch of the Reading Railroad was built, it cut through Mr. Clayton French's property, which was the cause of much litigation; whereas, they could have avoided it at much less cost by going around it, but their Chief Engineer of the road, Mr. Lorenz, said "No! To go around will cause a detention of at least five minutes for each train, and twenty trains a day means 100 minutes," and the road was built straight.

Now, this company can secure an entrance into the heart of the city, without one cent of cost for the right of way, and a straight line at that, by coming in under Broad Street. By so doing, they

remove from public sight the locomotive and cars, and their existence will almost be forgotten.

A tunnel could be built from a point on Broad Street, where it intersects the Richmond branch, a distance of about three miles, at a cost of about \$4,000,000, whereas the present proposed route will cost at least \$10,000,000, exclusive of stations, etc.

This tunnel line would not involve the payment of damages to private property, and it would be entirely free from all grade crossings, or interference with the occupants of private houses, and the noise of passing trains, etc.

The tunnel plan has many advantages and should be preferred upon the grounds of taste and propriety alone, as it will spare us the boiler iron architecture that will cover over many of the principal thoroughfares, such as Arch, Race and other streets.

The following cut, *Fig. 8*, shows a section of tunnel road-bed and proposed station at or near Arch Street. The upper section shows the road-bed at Broad and York Streets, the difference in the height of the two road-beds being the difference in grade between the two points.

Stations can be located at any convenient points along the proposed line, access being had by stairs or elevator as may be desired.

[The estimate for additional cables, given on page 41, is based on statements made in a pamphlet entitled "A Warning from the Edison Electric Light Company," issued by the company within the last three months. On page 57, we read as follows: the "Price of Underground Conductors (complete) per lamp \$8.85, at Denver, Col., for 10,000 lights, and at Minneapolis, Minn., for 21,700 lights, feeders and mains, " \$2.40 per light," estimate made May, 1887. Also, on page 59, "Edison 3-Wire Direct System, \$4.40 per lamp," "September 1, 1887."]

COMMENTS OF PROF. WM. D. MARKS ON MR. LEVAN'S PAPER.

OFFICE OF THE EDISON ELECTRIC LIGHT COMPANY, OF PHILADELPHIA,
435 CHESTNUT STREET,

PHILADELPHIA, June 13, 1888.

Dr. Wm. H. Wahl, Secretary FRANKLIN INSTITUTE.

DEAR SIR :—Mr. W. Barnet LeVan's assumptions with regard to the Edison Electric Light Company's new central station are so

wholly incorrect as not to admit of being used as the basis for any argument. I cannot make any further reply than to express my extreme regret that the Publication Committee, in spite of my repeated protests, should have permitted the publication of an attack upon the business of this company by a person absolutely without the means of knowing, and who has made no attempt to obtain, the necessary data for a fair discussion. Kindly publish this as an appendix or note to that part of Mr. LeVan's paper relating to the Edison Company.

Yours truly,

WM. D. MARKS, *Supervising Engineer.*

A STATEMENT BY THE COMMITTEE ON PUBLICATIONS.

THE Committee on Publications desires to explain that, in accordance with the usual custom, the paper of Mr. LeVan, which had been read at one of the stated meetings of the INSTITUTE, was submitted to it for publication in the JOURNAL; that several protests against the publication of the paper were received and considered; and that it was decided to publish the paper and to give the protestants the opportunity of making reply thereto in the same impression of the JOURNAL.

The Committee's proffer elicited a reply from Prof. Marks, printed above. In view of the statements contained therein the Committee deems it proper to state that, in its judgment, the paper of Mr. LeVan appears to be a criticism of the engineering methods of certain local companies, based largely upon descriptive accounts of the same that have appeared in the daily press; and that it contains neither personalities, nor any attack upon the business of any person or company. The Committee, therefore, sees no valid reason for reversing its decision to publish Mr. LeVan's paper.

THE COMMITTEE ON PUBLICATIONS.

PHILADELPHIA, *June, 27, 1888.*

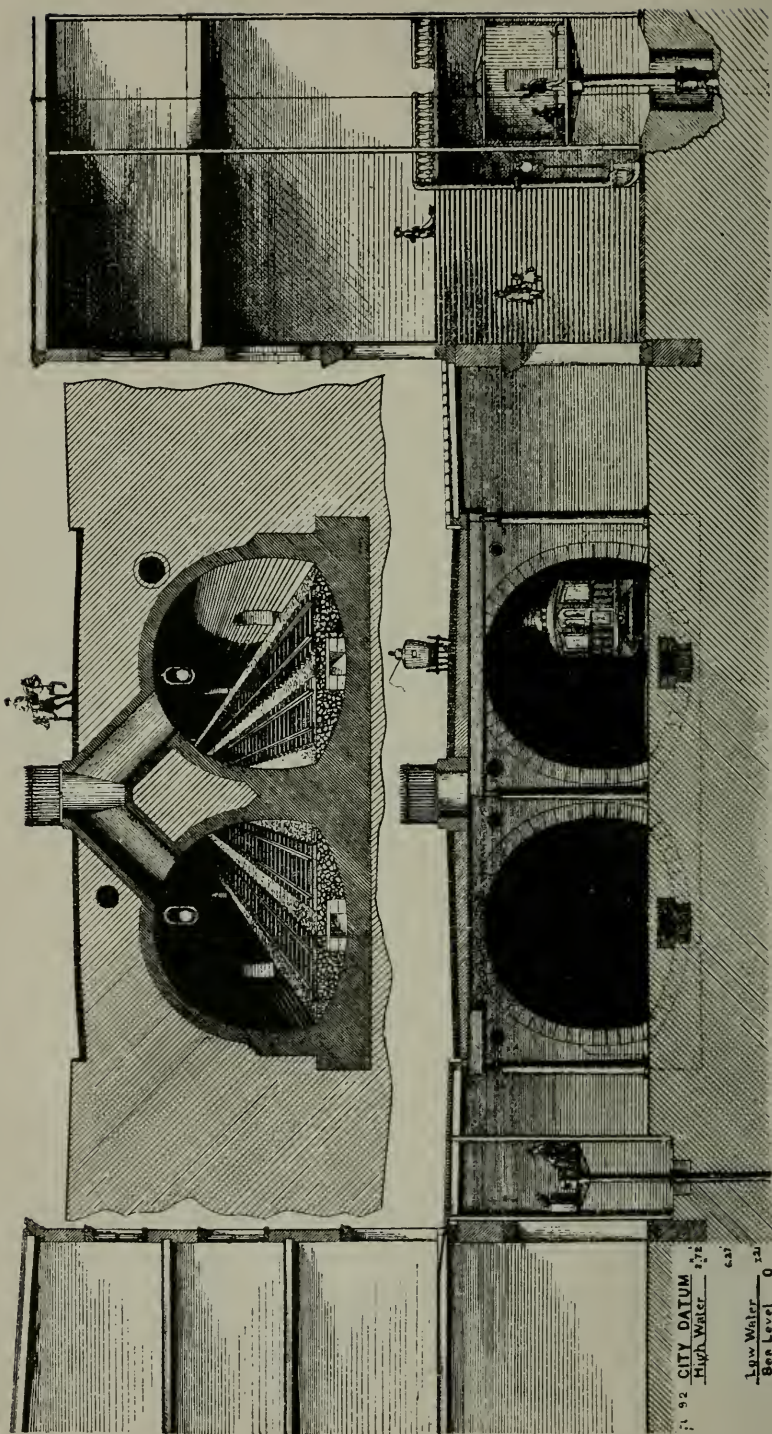


FIG. 8.

MOVEMENT OF UPPER AIR CURRENTS.

BY H. ALLEN HAZEN.

Prof. Ferrel says, *An. Rep. C. S. O.*, 1885, p. 259: "The principal cause of the progressive motions of cyclones is undoubtedly the general motion of the atmosphere in which the cyclone exists. The velocity of progressive motion, however, is generally much greater than that of the general motion of the atmosphere, even up at a considerable altitude." Prof. Ferrel finds that Prof. Loomis has obtained a velocity of twenty-six miles per hour for storm centres and he obtains, from a table on p. 213, that this velocity for the middle latitudes of the United States would be found at an altitude of 16,400 feet, and he considers that if the progressive motion of the storm is due to that of the upper air currents, then "the centre of the controlling power of the cyclone must be at that altitude." Without at present considering the theoretical determinations of velocity in the upper strata, it will suffice for my purpose to note that, according to Prof. Ferrel's views, there is a most intimate relation existing between the motions of the upper air strata or clouds and that of the storm on the earth. It is very easy to see that, since the motion of the upper clouds is far in advance of that of the storm, if only we can correlate that motion with that of the storm, we shall have a most important aid to weather and storm predictions. It shall be the object of this paper to make a beginning in this study, with the hope that others may be interested in the question, and also expecting sometime to continue it farther.

One of the most important considerations is as to the directions of the uppermost clouds when compared with the currents at a mile or a little more. We very frequently find the lower clouds going in directions differing greatly from that of the upper clouds, but it seems probable that in most of these cases the lower clouds are less than 6,000 feet altitude. The cirrus often attains a height of five or six miles, and the study of the movements of the upper strata would be much simplified if we could obtain the relation, if any subsists, between the movements of the upper and lower currents. Fortunately we have in this country a peak, well isolated, rising to a height of 6,300 feet, and offering, it would seem, a most inviting and excellent vantage ground for observation. I have studied the

records of the movement of upper clouds and the wind at Mt. Washington, and have found a remarkable uniformity in the motions, *i. e.*, almost without exception the two motions either agree or differ by only 45° . It is easy to see that the recorded difference of 45° , *e. g.*, W. for the wind and N. W. for the upper cloud, may mean a difference less than 5° between the two, for the wind may be N. 70° W., which would be recorded as W., while the clouds may be N. 65° W., which would be recorded as N. W. The actual difference in this case would be only 5° . It would seem a very good plan to make an additional record at such stations as Pike's Peak and Mt. Washington, giving the actual angle between the two directions, or it may be better yet to give the wind as so many degrees east or west of the north and south points, and likewise the clouds. The exceptions to the usual rule, that the upper currents and those at 6,300 feet have the same direction, are very interesting and need to be studied by themselves. We may consider, in general, that above the height of 6,000 feet there is very little variation in the direction of motion of the air strata from that height up to the limit of plainly visible cirrus cloud. I am not aware that we have any records of the motion of the highest ice spiculæ as compared with the upper cirrus, but this would seem a valuable desideratum.

Another important fact to be determined is the relation, if there be any, between the surface wind and the air current at 6,000 feet. Prof. Loomis has made such study by comparing the winds at Burlington and Portland with those at the same time on Mt. Washington, but this method of research can hardly be considered satisfactory. The region within 100 miles of both these stations is very mountainous and the proximity of Portland to the sea, where the actions of storms cannot be determined, precludes the possibility of satisfactory determinations. It would seem, however, that if we project the direction of the upper clouds on charts containing isobars, we shall have a good opportunity of studying the relations between them, and if we know, as we do, the relations between isobars and surface winds, we can immediately ascertain the relations between upper current directions and that of the surface winds. A discussion of this question, however, must take into consideration the fact that in the centre of a high area there are frequently no clouds and in the centre of a low area

there are so many dense clouds that often no motion can be determined. Nevertheless, this loss is not serious, because the direction at some distance will in general be that near the centre. The gap in the case of a clear sky may readily and inexpensively be filled by observations of toy balloons. It is probable that, at an expense of less than ten cents, a balloon can be made to rise to the height of 3,000 feet, and up to 6,000 feet at less than twenty cents. When we consider the enormous advantage to be derived, even from a single well made ascension of this kind, the above sum is paltry enough ; dollars have been spent for single observations of far less value. The advantage of these balloons would be very great, they could be used in determining the approximate height of a dense and apparently uniform stratus or nimbus and its velocity can be very readily determined in an inexpensive way. I suggest only one method, perhaps the least expensive of any. Let two men have their watches compared very carefully or let them be stationed so that the one can see a flag at the other station. Let a flat plate of tin, two to three feet long and one foot wide, be suspended from a short edge by two cords so arranged on a circular disk that the plate may be set at any vertical angle from the meridian. Let the observers be about 1,000 or perhaps 2,000 feet apart and let the balloon be sent up, if possible, so far from the observers and to the windward, or in the direction in which the upper current is moving, that it shall have reached approximately the highest point of its ascension before it passes the first observer. The height may be readily adjusted by weighting the balloon. As the first observer sees the balloon coming, let him place the plane of his plate exactly at right angles to the path of the balloon and place his eye so that its line of sight will lie exactly in the plane, let him signal the moment the balloon passes his line of sight or note the time, and if the second observer notes the time of passage over his plate, set the same way, we shall have the data for the velocity of the balloon. If it takes one minute to go the distance between the plates, the velocity will be about seventeen feet per second, if the observers are 1,000 feet apart. It may sometimes be necessary to send up one balloon in order that the observers may get approximately in the line of motion. This simple method will do away with the more cumbersome and expensive method of observations of angles.

In studying the relations between cloud movements and isobars, I have had projected all upper cloud movements observed at all stations of the Signal Service for the month of April, 1887, for the 3 and 10 P. M. maps. These charts showed several characteristics of the highest interest. There was a well-marked and general tendency of the movement of clouds toward the east at all times when there were no well marked low or high areas near. In the latter cases there was an undoubted circulation of upper clouds precisely similar to that of the lower winds, *i. e.*, with the motion of watch hands or away from a high area, and counter-clockwise or toward a low area. Whether one or the other of these directions was taken, depended largely upon whether it was in a direction toward the east, *i. e.*, a motion away from a high area was turned slightly in a direction clockwise whenever it would bring it nearer to the regular easterly movement. There was also a slight tendency at the more southerly stations toward a motion from the S. and S. W.

One of the most tenaciously held theories of tornado formation is that it is caused by the meeting of warm southerly and cool northerly winds. Afterward it was shown clearly that tornadoes occur in the S. E. quadrant of a low area hundreds of miles from the nearest north winds. Now we are told that the cause is as follows: the warmer surface wind from the south underruns the upper current from the north, thus producing an unstable equilibrium. At first sight it might seem impossible to determine this one way or the other, but fortunately, during the occurrence of tornadoes, the upper clouds may almost invariably be seen. A careful study of these upper clouds, in connection with tornado formation, has shown, as already noted, in general, a uniform and steady current from the south or southwest exactly coinciding with the motion of the surface wind.

The other element we wish to study in connection with cloud movements is their velocity. Prof. Ferrel thinks this gradually increases as we rise in the atmosphere, but he does not give any figures showing how far up this increase goes on. This is certainly a very important matter. We can obtain the approximate velocity by the wind on Mt. Washington, but this would be up to only 6,300 feet, the height of the anemometer cups. The following method is suggested for determining an approximate relation

between these velocities. A balloon kept at 6,000 feet or even 10,000 feet altitude will move exactly with the current at that height, and its velocity can be told by observations of the places it passes over; now, if the balloon does not revolve when it moves horizontally (the motion if any is very slight) it will be possible to tell whether the clouds above are moving faster, slower, or with the balloon. Of course, the velocity can very exactly be determined by sending up balloons, which shall move horizontally after attaining a certain height, as already suggested.

Turning to the observations on Mt. Washington, I have made a very careful study of the records for the year May, 1886, to April, 1887. Great caution must be used in assuming that we have here the exact motion, either in direction or velocity of the air strata at this height; I do not think we do. It should be noted that while the sides of the mountain deflect the air upward and give too great an air motion, yet this is counterbalanced in part by the fact that in many months of the year cold and frost vitiate largely the amount of motion that really occurs; this is specially the case with average velocities. In order to obtain an approximate observation of the difference between the actual wind velocity and that recorded by the station anemometer, an instrument was placed upon a high signal tower on the summit. This was forty feet above the summit and exactly the same amount above the station anemometer. If more air passes over at the surface than some distance above, the upper instrument should give the less velocity, though it is impossible to determine at what point the true velocity could be ascertained. It should be noted that the station anemometer may be slightly affected by a sloping roof. Comparison for a single month showed that the higher anemometer gave about eight per cent. less velocity than the lower. It is probable that the only method of getting the accurate movement would be to allow toy balloons to cross over at 100 or more feet above the summit, though an approximate result could be determined by means of an iron column 100 feet long having anemometers at vertical distances of about twenty-five feet. Of course whatever deductions may be made, in regard to winds at different times, would be affected in like manner by this cause. Bearing these points in mind, we are prepared to study the wind velocity on Mt. Washing-

ton. I divided all the 365 days in the above period into three groups. (1) Days of wind where there was a well-marked low area within about 400 or 500 miles of Mt. Washington, 164 cases. (2) All cases in which there was a high area, either over or very near the station, seventy-three cases. (3) The remaining cases, which I will call "between," 128. It will be seen easily that often these cases would run into each other and it would be difficult to assign each to its proper position.

AVERAGE WIND VELOCITY ON MT. WASHINGTON DURING THE PASSAGE OF LOW AND HIGH AREAS
AND ON DAYS BETWEEN.

LOW.					HIGH.			
Month.	Cases.	Mean Max.	Mean.	Velocity of Storm.	Cases.	Mean Max.	Mean.	
May, . .	16	65.4	45.9	25.5	2	32.0	16.5	
June, . .	12	60.0	49.2	28.5	9	26.4	13.0	
July, . .	14	62.2	45.4	32.6	6	39.8	20.8	
August, .	11	70.5	52.3	27.7	14	32.1	19.1	
September	13	73.9	53.5	36.6	9	34.3	19.4	
October, .	8	62.5	46.9	29.6	11	33.0	19.2	
November	16	68.1	50.0	32.2	2	62.0	41.5	
December	13	77.3	58.8	35.9	5	41.6	23.2	
January, .	21	82.0	65.2	40.1	2	41.0	30.0	
February, .	16	89.8	65.0	45.7	6	56.0	35.7	
March, . .	11	68.8	45.0	38.0	1	60.0	45.0	
April, . .	13	71.0	51.2	31.8	6	39.3	21.2	
Mean, . .	164	72.6	53.3	34.2	73	37.1	21.6	

" BETWEEN."					MEAN RESULTS.				
					Cases.	Mean Max.	Mean.	Velocity of Storm.	
May, . .	13	41.5	23.2		Low area, . .	164	72.6	53.3	34.2
June, . .	9	40.8	24.3		High area, . .	73	37.1	21.6	
July, . .	11	49.3	29.2		Between, . . .	128	57.2	37.7	
August, .	6	37.7	22.8						
September	8	61.5	41.4						
October, .	12	60.1	38.2						
November	12	52.5	32.9						
December	13	63.8	45.4						
January, .	8	73.0	50.4						
February, .	6	66.7	50.0						
March, . .	19	67.3	45.6						
April, . .	11	64.9	45.3						
Mean, . .	128	57.2	37.7						

I have no doubt that a more careful gleaning would tend to give higher velocities near a low area and lower velocities near a high area, so that these deductions will be safe. In the case of

the low areas near the summit, I took out on each date: (1) The direction and distance of the low area from the summit; (2) The maximum velocity of the wind during the twenty-four hours, with its direction; (3) The mean velocity of the wind for twenty-four hours; and, (4) The mean velocity of the low area as it approached and moved away from the summit. For the high area I took out only the maximum velocity in twenty-four hours, together with the mean velocity for the same time. The latter method was also followed in the "between" cases. A summary of the results of these observations is given in the foregoing table:

We see from this table that the velocity is greatly increased when there is a low area near the summit, and the velocity of the wind far exceeds that of the progressive motion of the storm. The latter deduction is very remarkable, and is directly opposite to the theoretical results obtained by Prof. Ferrel. It would seem as though either the cause of the progressive motion of the storm centre is distinct from the motion of the general current, or else that its seat is considerably below the summit of Mount Washington. There is one consideration in favor of the first supposition, in the fact that the fluctuations of pressure at the highest stations, such as Pike's Peak and Mount Washington, are nearly the same in amount as at sea level.

Since Prof. Loomis has determined that the "power" of the storm is generally below 6,000 feet, and since balloon observations rarely show rain much above that point, it would seem as though the idea that this "power" may be at a height of 16,400 feet, and also that the progressive motion of a storm is much greater than that of the atmosphere, even up to a considerable altitude, would need to be much modified. It is certain that the theoretical determination of twenty-six miles per hour for the current at this height cannot be accepted.

CONCLUSIONS.—(1) The upper currents of the atmosphere, while having a general motion to the eastward, at the same time have a motion about high and low areas similar to that of the surface winds.

(2) The upper cirrus clouds, in general, have a motion similar to that of the currents at about 6,000 feet elevation.

(3) The velocity of the currents at about 6,000 feet is less than half at a high area that it is at a low area. This may be an explanation of the fact that the maximum daily winds at mountain stations come at about sunrise and the minimum at the hottest part of the day. May not the heat after the middle of the day expand the air sufficiently to cause a rise in pressure somewhat similar to a high area, and hence the diminution in the wind velocity?

(4) If the progressive motion of storms is dependent on that of the general upper air currents, then the motion of the lower clouds, or at least of those below 6,000 feet, must indicate much more clearly the direction of the storm than the upper clouds.

(5) It would seem possible to determine quite closely the path of an advancing low area, if we know the height and direction of the clouds in front of it.

(6) It seems probable, from the enormous increase of velocity of the upper currents in the neighborhood of a low area, that this rapid increase in velocity will account, if not entirely, still largely, for the intensity of the storm.

(7) It was determined in 1884 that thunder-storms, in the southeast quadrant of a low area and often 600 miles from its centre, frequently attained a velocity double that of the accompanying low area. That they gained upon the low area, during the day hours, to die out at night and begin again at a point a little east of the point where they began the day before, perhaps about as far east of that point as the low area had moved toward the east, and from thence repeat the movements of the previous day. I throw out, as a suggestion, that possibly these storms rise to a height somewhat in excess of that of the "power" of the low area, and hence, having reached a current moving more rapidly than that of the low area, they are transported much more rapidly. This would be a plausible explanation if we consider that the progressive motion of the flow area is caused by that of the current wherein its "power" is seated.

We may well conclude finally that herein is presented a most promising field of research for those who would be weatherwise.

GENERAL THEORY OF JOINTED BOW GIRDERS.

BY E. A. WERNER, C.E.

(Continued from Vol. cxxv, page 499.)

I turn now to the strains themselves :

CHORD STRAINS.

$$U_m = \left(\frac{M}{h} \right)_m \pm H.$$

The chord strains always consist of the strains of the moments and when the chord takes up the thrust, also of the thrust.

As W is the increment of the chord strains from point to point, U will increase or decrease as long as W does not change its sign and will have a maximum or minimum with $W = 0$, while U itself can be either positive or negative.

Hence, in constructing the curve of U , in using U as y , we shall have in any girder the following figure for the chord strains near the point $W = 0$, and we see at once that with the change of the sign of W is connected a change in the direction of the action of U , in consequence of the maximum of U corresponding to $W = 0$. We deduct thus the

Rule.—A change of the sign of W reverses every time the direction or the sense (*not the sign*) of the chord strains U .

Rule.—The chord strains have relative maxima and minima in those points on the right and left, of which W is of different sign.

In the difference $\Delta U = U_m - U_{m-1}$ each factor can be of any sign, so that with a positive and negative moment the action of W still can be positive. Hence, we have the

Rule.—The sign of U is independent of the sign of W .

From $W = U_m - U_{m-1}$ follows furthermore :

Rule.—If *no tie* is acting in a panel point, the horizontal component of the chord strains at the right and left of the panel point have the same value.

TIE STRAINS.

We have :

$$W_m = \left(\frac{M}{h} \right)_m - \left(\frac{M}{h} \right)_{m-1} = U_m - U_{m-1} = \Delta U.$$

From it follows directly :

Rule.—The *horizontal component* of the *tie strains* always is *equal* to the *difference of the horizontal components of the chord strains* at the right and left of the panel point.

From this rule we deduct then the very important

Rule.—The *tie strains* are *independent of the thrust of the structure*.

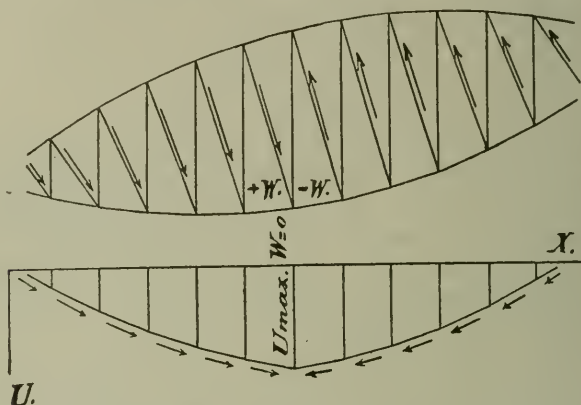


FIG. 7.

We know that a change of the sign of W implicates every time a change in the direction of the chord strains. We have thus:

Rule.—The sign of W indicates the *direction* (not the sign) of the action of the chord strains and: (see Fig. 7.)

Rule.—If the same kind of ties shall be used throughout the structure, it is necessary to reverse each time, that W changes its sign, the direction of the tie.

It remains now to define the position of the loads creating the MAXIMAL AND MINIMAL STRESSES IN THE MEMBERS OF THE TRUSS.

Considering to that effect the expressions of D , E , B , W , U , P , we see that all these expressions are simply algebraical sums of the moments and the thrust. Hence in substituting M and H expressed in G_1 G_2 G_3 in the equations of the above forces, all these forces will be of the same form:

$$\text{Strain} = a G_1 g_1 + b G_2 + c G_3 (l - g_3)$$

herein will be:

a , b , c the algebraical sums of the coefficient a b c of each single

factor composing the strain, while the action of G_1 G_2 G_3 will be regulated by the rule of the shearing forces, which gives the action of algebraical sums of moments.

As the coefficients a b c as well as G_1 G_2 G_3 have exactly the same signification in the above general equation of the strains as in the equation of the moments of the external forces, all the results obtained for the last ones, can be directly transferred to the above general equation of the strains and especially also the way in which the maximal and minimal value of the moments is found. The rule given there is thus quite general and reads:

"To find the maximal value of any strain in the member of a hinged bow girder, calculate or construct a b c , in adding or subtracting the corresponding a b c of each single factor composing the strain, calculate also the corresponding maximum line of G_2 from $b=0$ and fill those parts of the structure corresponding to positive values of a b c with loads, in using the greatest possible values of G_1 G_2 G_3 and vice versa for the minimal value of the strain."

The application of this rule will present no difficulty as soon as I shall have explained the way in which the greatest possible value of G_1 G_2 G_3 can be found.

As I have shown with the external forces the ordinates y and f are parting lines of the forces, that is: lines to the right and left of which the action of the forces is different, the ordinate of the line of maximum is the parting line of the positive and negative increments of the loads connected with the coefficient b , whatever be the way of loading or the numeric value of the loads.

These lines are in fact absolute divisions. If a and c are of different sign, any load producing a positive action in the part a , will produce a negative action in the part c . Nevertheless, as the total value of the strains is the algebraical sum of mostly three members, this total value can become greater, when, in filling the girder with loads, these parting lines are somewhat transgressed. Although producing in *one* part unfavorable actions of the loads, the special position of the loads in the other part, can produce so more favorable action, that the unfavorable action in the one part is more than counterbalanced and the total value of the strain greater than if the parting line had not been transgressed.

I can explain this in the easiest way with an example, using an ordinary square truss, of which the positions of the loads inducing

the maximal and minimal values of the stains are conversant to everybody.

If we make :

$$y = 0$$

$$G_3 = 0$$

in the equations, it follows :

$$m_m = \text{moments} = G_1 g_1 \left(1 - \frac{x}{l}\right)_m + G_2 x \left(1 - \frac{g_2}{l}\right)_m$$

$$V_m = \text{shearing forces} = - \left(\frac{G_1 g_1}{l}\right)_m + G_2 \left(1 - \frac{g_2}{l}\right)_m$$

$$W_m = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1}$$

For an ordinary square beam now we have :

$$h_m = h_{m+1}$$

and

$$W_m = \frac{M_m - M_{m-1}}{h_m}$$

or

$$W_m = \frac{h_m}{\int x_m} = N_m \sin a_m = V_m$$

or

$$N_m \sin a_m = - \left(\frac{G_1 g_1}{l}\right)_m + G_2 \left(1 - \frac{g_2}{l}\right)_m$$

or the strains in the ties become a maximum with the shearing forces.

Now,

$$b = 0$$

gives :

$$g_2 = w_2 = l$$

Hence the strain in the ties of a square beam is a maximum, when $G_1 g_1$ the negative part is empty and G_2 , that is that part from the end of the tie, to the right end of the structure is filled with loads.

Nevertheless it is known, that it will be necessary to shift the rollers of the engine over the parting line of $G_1 g_1$, in the negative

part of G_1 , in order to reach the absolute maximum of the strains, in fact to produce some negative strains in order to bring the heaviest loads on the second part of the girder. The increase of G_2 the positive strain is greater than the increase of G_1 and the total value of W greater, than if the rollers had not transgressed the parting line.

How far the limits must be trespassed in each case, depends of course upon the way of loading, but the same means, which give the positions of the loads inducing the maximal and minimal values of the strains in an ordinary beam, will also prove efficient in case of the bow and I think the above example has sufficiently illustrated the way to be followed.

With this the above rule for defining the positions of the loads creating the maximal and minimal values of any strain in the bow structure can be applied without difficulty. But the application can be made materially much easier by means of special arrangements, which I will now show. I begin with the :

STRAINS IN THE CHORDS.

We have :

$$U_m = a_n G_1 g_1 + b_n G_2 + c_n G_3 (l - g_3)$$

$$U_m = \left(\frac{M}{h} \right)_m \pm H$$

The equation includes three cases :

First, $H = 0$; second $\left(\frac{M}{h} \right)_m = 0$, and third, H and M not zero.

(1) $H = 0$ or the chords take up no thrust. Then $U_m = \left(\frac{M}{h} \right)_m$

becomes a simple function of M , and has its maximal and minimal values with the positions of the loads inducing the maximal and minimal values of M .

(2) $M = 0$ or the chords take up the thrust only. Then $U_m = H$ becomes a simple function of H and has its maximal and minimal values with the maximal and minimal values of the thrust.

I will again mind the reader to be very careful in calculating U , as the case that M becomes zero commands every time its own,

quite different position of the loads for the maximal and minimal values of U .

(3) *The chord takes up the combined action of the moments and the thrust.*

In this case, the coefficients a b c of U are still so simple that the positions of the loads inducing the maximal and minimal values of U easily can be constructed graphically

If we consider to that effect the equation :

$$h_m U_m = G_1 g_1 \left(1 - \frac{2fx + l(y \pm h)}{2fl} \right) + G_2 \left(x - g_2 \frac{2fx + l(y \pm h)}{2fl} \right) + G_3 (l - g_3) \left(\frac{2fx - l(y \pm h)}{2fl} \right)$$

which is obtained, when the coefficients of H are added or subtracted from the coefficients of M , we see that this equation is exactly the same as that of the moments :

$$M_m = G_1 g_1 \left(1 - \frac{2fx + ly}{2fl} \right) + G_2 \left(x - g_2 \frac{2fx + ly}{2fl} \right) + (G_3 (l - g_3) \frac{2fx - ly}{2fl})$$

when we use in the latter in place of y , the ordinate $(y \pm h)$.

As h is the depth of the stiffening truss in the point x_m y_m nothing is easier than to draw the curve corresponding to $(y \pm h)$. I shall call this line

“ THE DIRECTRIX OF U .”

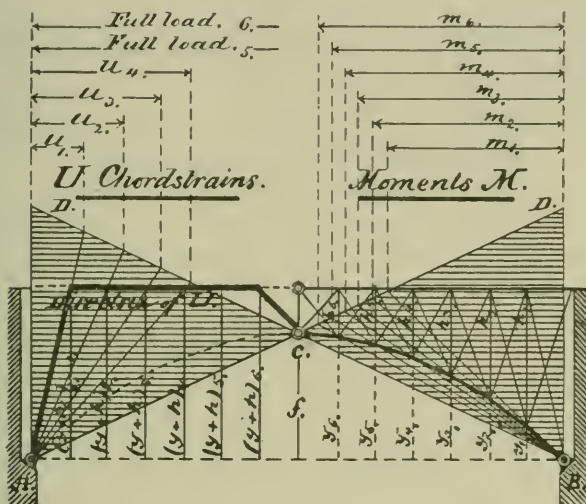
The directrix of U is to U exactly the same what the line of thrust is to the moments and the deductions made for M can directly be applied to U .

Hence to find the maximum line of G_2 for U or $g_m = u_m$ draw the directrix of U in adding or subtracting the height of the stiffening structure from the corresponding y of the line of thrust, and draw the deciding triangle. The abscissa of the intersection of the two lines DC and $A(y \pm h)$ will then locate the line of maximum of G_2 or

$$u_m = g_m = \frac{2flx}{2fx + l(y \pm h)} \quad (IV^a)$$

For the rest we know from M that, when the directrix of U lies outside the deciding triangle, the maximum of U is reached with full loaded girder.

Fig. 8.



The directrix will be used to advantage for calculating $a_n b_n c_n$, the coefficients of U , which are needed for defining the maximal and minimal values of P and W .

The coefficients $a_n b_n c_n$ can also be calculated in adding (or subtracting) $a b c$ of $H = \frac{1}{2f}$ to the values of $a b c$ corresponding to $\left(\frac{M}{h}\right)$.

STRAINS IN THE TIES.

We have :

$$W_m = U_m - U_{m-1} = \frac{M}{h}_m - \frac{M}{h}_{m-1}$$

or

$$W_m = a_w G_1 g_1 + b_w G_2 + c_w G_3 (l - g_3)$$

The coefficients $a_w b_w c_w$ are calculated in subtracting either the values of $a b c$ corresponding to $\left(\frac{M}{h}\right)$ or U . In putting then $b = 0$, the value of w_m , the maximum line of G_2 , is easily found.

In the first panel, and the panel before the top joint, $\left(\frac{M}{h}\right)_0$ or $\left(\frac{M}{h}\right)_n$ is zero, and hence W a simple function of M .

The division of G_1 is thus for W_1 and W_2 the same; also for W_{n-1} and W_n .

The calculation of W_m is much simpler when the girder has parallel chords.

It is then $h_m = h_{m+1}$, and

$$W_m = \frac{M_m - M_{m-1}}{h_m} = J S_m \cdot \frac{J x_m}{h_m}$$

or

$$W_m = N_m \sin \alpha_m$$

and W is simply a function of S .

STRAINS IN THE POSTS.

We have :

$$P_m = W_m \tan \alpha_m + U_m \tan \rho_m - U_{m-1} \tan \rho_{m-1} \pm E_m \mp g_m$$

or

$$P_m = a_p G_1 g_1 + b_p G_2 + c_p G_3 (l - g_3) \mp g_m$$

The calculation of $a_p b_p c_p$ is made in adding together the respective coefficients $a b c$ of W_m , U_m , U_{m-1} and E_m .

P is the most intricate strain. Its expression differs in two regards from the expression of the other forces. First in containing the member $\mp g_m$, and, second, in being often not reversible for maximum and minimum.

The first property, the member $\pm g_m$, would greatly complicate the definition of the positions of the loads inducing the maximal and minimal values of P , if it could not be eliminated. Luckily *two* expressions, one from the upper and one from the lower chord, for one and the same P are at our disposal. The first step to find the positions of the loads inducing the maximal and minimal values of P is thus :

RULE.—*Always select that chord of the stiffening structure, which takes up no moving loads, for defining the positions of the loads corresponding to the maximal and minimal values of P .*

The member $\pm g$, expresses then only the action of its own weight, or becomes a constant, without influence on the maximal and minimal values of P .

The second property named above, that the equations of P not always are reversible, or that from one and the same equation not always can be deducted the position of the loads inducing the maximal and minimal values of P , is the consequence of the action of W . The point of application of W' and W'' , or of N' and N'' in the same panel is the bottom and top of the post. Hence, when in reversing the positions of the loads, W'' becomes acting, it will be necessary *to use the special form for W'' in order to find the maximal and minimal value of P* , as the expression of P with W' cannot give the action of the forces corresponding to W'' . On the other hand, *when in reversing the loads the same tie remains in action*—as for instance when the same tie is used for compression and tension—one and the same expression of P will give the position of the loads for the maximal and minimal values.

Still another value of P must be investigated. That corresponding to the action of *two* or *no* tie, or to $W = 0$.

To that effect it is necessary to find first the points in which W becomes zero.

This investigation is generally not difficult by using the general equations of W .

But only those points, for which W is of different sign to the right and left of the point of application, correspond to a maximum or minimum of U , as only in these points the increment of U or W passes from the positive to the negative.

These points selected, the numeric values of P must be calculated and in comparing these values with the other values of P corresponding to the action of one tie, the absolute maximal and minimal values of P can finally be pointed out.

D, E, B, STRAINS IN THE MEMBERS OF THE BOW STRUT, THE SUSPENSION RODS AND THE SUSPENDED ABUTMENT.

All these strains are simply functions of the thrust, and reach thus their maximal and minimal values, with the maximal and minimal values of H .

Herewith the second part of our problem, to wit :

"To determine the positions of the loads creating the maximal and minimal values of the strains in the members of the bow structure, and the rules governing these positions of the loads—" is now solved and I will, as conclusion, resume here the

COURSE OF THE CALCULATION.

Calculate :

(1) *The data for calculation* as: the ordinates of the form of the line of thrust, $\alpha, \beta, \gamma, \mu$, etc.

(2) *The coefficients*

(a) by means of *the deciding triangle* and the *line of thrust* for

$$\left(\frac{M}{h}\right)$$

$$\frac{\xi' - y}{2fh}, \quad \frac{\xi + y}{2fh}, \quad \frac{\xi - y}{2fh},$$

(b) by means of the *deciding triangle* and the *directrix* of U , for U

$$\frac{\xi' - y}{2fh}, \quad \frac{\xi + y}{2fh}, \quad \frac{\xi - y}{2fh},$$

Check. The values of the above coefficients are different by the value of $a b c$ of $H = \frac{1}{2f}$.

(c) by simply *subtracting* either the coefficients of

$$\frac{M}{h} \text{ or of } U,$$

the *coefficients* of W .

Check. The values must be the same whether U or $\left(\frac{M}{h}\right)$ is used.

(3) *Form the general equations of* $\frac{M}{h}$ U, W , construct or cal-

culate the corresponding lines of maximum of G_2 with $b = 0$, select accordingly the positions of the loads inducing the maximal and minimal values of the above strains, and calculate their numeric values.

(4) *Calculate for* $\frac{M}{h}$ and U the *course of the ties* correspond-

ing to the positions of the loads inducing the maximal and minimal values of these strains, and determine the direction of U . The direction fixed, calculate the maximal and minimal values of A and

T , and also by means of W the maximal and minimal values of N or N' and N'' .

(5) Find out by means of the general equations of W the points in which W passes through zero, or the points to the right and left of which W is of different sign.

(6) Calculate by summing up algebraically the corresponding coefficients of the composing forces the coefficients of P , when :

- | | |
|-------------------------------------|---------------|
| (1) The ties W' | } are acting. |
| (2) The ties W'' | |
| (3) Two ties or no ties, or $W = 0$ | |

Put up the corresponding general equations of P and calculate the maximum lines of G_2 . Construct the corresponding positions of the loads inducing the maximal and minimal values of P , and calculate finally their numeric values.

Check. The values of the strains of P must be the same, whether calculated from the top or the bottom chord. That chord which takes up no moving loads must be used without exception for defining the coefficients of P and its general equations.

(7) Calculate the values of D , E , B directly from H .

I shall now show the application of these rules in an example.

(To be continued.)

ON SOME EARLY FORMS OF ELECTRIC FURNACES.

No. 8. WERDERMANN'S ELECTRIC FURNACES.

BY PROF. EDWIN J. HOUSTON.

Richard Werdermann, well-known to the scientific world in connection with his semi-incandescent electric lighting system, has made a number of ingenious applications of electrical currents to metallurgical purposes, some of which may properly be ranked under the general heading of electric furnaces.

The earliest of Werdermann's electric furnaces is described in Brit. Patent No. 474, of 1873, for an "Improved Method of Reducing and Purifying Metals," and dated February 10th, 1873.

Werdermann's process does not differ materially from that practiced by other inventors. The ore to be treated is first crushed and then raised by ordinary heat up to a red heat, when the metal is extracted by sending through it an electric current, led into and through the heated mass by terminal electrodes of carbon, platinum, or other refractory substances that are conductors of electricity. The electric source proposed by Werdermann was either a voltaic battery or a dynamo-electric machine.

Werdermann proposed to employ his process of electric reduction either in connection with or independently of the reducing action of carbonaceous matter.

The following description of his process is taken from the specification of the above mentioned British patent, viz :

"My invention relates to an improved mode of applying electric currents in order to reduce metals directly from their ores with or without the ordinary chemical action of carbonaceous matter, and in purifying and refining at the same time and by the same process the metal during its reduction from the ore.

"The ores, that is to say, oxides, sulphides, carbonates, or other combinations in which the metals exist in nature are first crushed, and then heated in a suitable furnace or retort.

"After the whole charge is raised to a red heat, two pieces of carbon or platinum or some other suitable material which conducts electricity, are plunged in the crushed ore. These two pieces are

connected by a platinum or other suitable wires or ribbons with the two poles of a galvanic battery or magneto-electric machine."

Werdermann mentions the necessity for properly regulating the electro-motive force and current employed. He describes the applicability of the current to the operation of *electric puddling*, and states the saving in time thereby effected.

"By regulating in a suitable manner the electro-motive force and the intensity of the electric current, and stopping it at the proper moment, cast iron, wrought iron, or steel can be produced directly from the furnace without any intermediate operations. This puddling by means of an electric current will occupy from ten to fifteen minutes only, instead of several hours as in the ordinary puddling by hand labor or machinery, and consequently a great saving of time will be effected."

The application of electricity to the puddling furnace would appear to possess great promise, and it is singular that the process has not as yet been carried into actual extended use. It is probable that a difficulty has been found to arise as regards the proper regulation of the current, and the quality of the wrought iron produced, should the process be stopped either too soon, or not soon enough.

In Brit. Patent No. 1933, of 1873, Werdermann describes a process for the production of aluminium in which, reversing the order of sequence, electricity is first employed, and heat afterwards. This process consists, briefly, in acting electrolytically on common salt and thus reducing it to a sub-chloride Na_2Cl , or Na_1Cl_2 (?) This chloride is then reduced to a powder and mixed with cryolite, or chloride of aluminium, or with double chloride of aluminium and sodium in sufficient quantity for the reduction of the aluminium. The mixture, with or without suitable fluxes, is then to be heated to redness in a reverberatory furnace, when, it is claimed, the reduction quickly takes place. The practicability of this process must be considered very doubtful.

In 1874, Werdermann invented a process for the cutting of rock by the heat of the voltaic arc. This process, though affording an excellent illustration of the application of powerful electric currents, can hardly be ranked under the head of electric furnaces, unless it may be regarded as a species of blast or reverberatory furnace for the fusion of refractory substances.

Werdermann applied his invention by causing the electric current to pass between two carbon sticks or electrodes placed parallel to each other. The arc was formed at their extremity by causing the current to pass up one of the carbons and down the other.

It will be noticed that Werdermann's invention of the electric blow-pipe in reality anticipates the invention of the Jablochkoff electric candle, in which two parallel carbon electrodes are used, as in Werdermann's apparatus, for the production of light instead of heat.

Werdermann patented his invention in England in patent No. 1,438, of 1874, under the title of "An improved method of cutting rock or stone and other hard substances, applicable for tunnelling, mining, quarrying, shaping, or dressing stone, and for other like operations." The patent is dated April 24, 1874.

The following description is taken from the specification of the other patent :

"The said invention consists mainly in the application of intense heat to the rock or other substances to be cut, crushed, or perforated, and is carried into practice in the following manner : On a rod or stem of cast iron or other suitable material is fixed a set of powerful air or steam blow-pipes at such distances apart as to cover when in operation the entire surface of the rock to be cut or penetrated. * * *

"When the rock is very hard, as porphyry, granite, gneiss, and the like, I prefer to use an electric blow-pipe in the following manner: The carbons of the electric light are fixed on a suitable handle provided with screws to regulate by hand the distance of the carbon points. At equal distances from the carbon points are arranged the two poles of a powerful electro-magnet. As soon as the light is produced, and the electro-magnet set in action, the voltaic arc is repelled and pointed like the flame of the blow-pipe. The same effect is obtained in blowing through the voltaic arc between the two carbon points a powerful current of air or steam or other suitable vapor or gas.

"The heat obtained by such an electric blow-pipe is so intense that the hardest granite not only calcines but fuses in a few seconds."

The ingenious application of an electro-magnet for the purpose of directing the arc against the surface to be acted on, is similar to the use of the coil placed around the electric crucible of Siemens

for preventing the arc from playing against the sides of the crucible, and directing it on the substance that is to be fused.

In Brit. Patent No. 4,805, of 1876, dated June 12, 1877, Werdermann patented the use of parallel carbons, suitably insulated from each other, for the production of the electric light.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, April 7, 1888.

OBITUARY.

~~MR. CURTIS BOOTH.~~
JAMES CURTIS BOOTH.

In preparing a minute of the death of Prof. JAMES CURTIS BOOTH, your committee feels that it is not inappropriate to quote the following concise and authentic biography from the illustrated history of the United States Mint, 1885 (published by G. G. Evans, Philadelphia):

"JAMES CURTIS BOOTH, melter and refiner, United States Mint, Philadelphia, was born in Philadelphia, 1810; educated in the same place and was graduated from the University of Pennsylvania, 1829, after-study and field practice in the Rensselaer School, at Troy, N. Y., in 1831 and '32, under the late Prof. A. Eaton.

"Mr. BOOTH derived his knowledge of practical chemistry in Germany in 1833, '34 and '35, in the laboratories of Profs. F. Wohler and G. Magnus, and in visiting accessible manufacturing establishments in Germany and England.

"The late Prof. J. F. Frazer and Mr. BOOTH were the two assistants on the Geological Survey of Pennsylvania in its first year, 1836. Mr. BOOTH next had charge of the Geological Survey of Delaware, in 1837 and '38 (being assisted by Prof. J. F. Frazer), and published his report of the Survey in 1839 and '40.

"Mr. BOOTH, observing the great necessity for a knowledge of applied chemistry in his native place, opened a laboratory for teaching the same by chemical analysis and by operative work in 1836, and the laboratory then established has been continued successfully to the present time by Mr. BOOTH, in association with Mr. T. H. Garrett and Mr. A. Blair. Having the same object in view, Mr. BOOTH lectured at the FRANKLIN INSTITUTE for nine (9) successive winters, there giving three full courses of lectures upon

chemistry applied to the arts, each course of three winters' duration, 1836-45. In 1843, Mr. BOOTH published the 'Encyclopædia of Chemistry,' he being the author of the majority of the articles contained in it, with valuable contributions by Prof. R. S. McCullough and others. It proved and continues to be a substantial adjunct to the study of chemistry."

It should be borne in mind that when Prof. BOOTH delivered lectures upon chemistry at the FRANKLIN INSTITUTE, the facilities for scientific and chemical instruction were very limited as compared with those of the present time.

The system of public education which supplanted the "poor schools" was upon trial, and the FRANKLIN INSTITUTE furnished from among its members the promoters of popular education, and was in itself an important and conspicuous participant in the work of diffusing useful knowledge.

Under these conditions, the services rendered by Prof. BOOTH deserve to be ever remembered. The classes instructed are well represented among the enterprising and successful professional and business men of the present day.

The lectures of Profs. J. F. Frazer, JAMES CURTIS BOOTH, J. C. Cresson, W. R. Johnson and Dr. J. K. Mitchell gave an enduring character to the instruction of this INSTITUTE, which can never be forgotten.

The Director and officers of the Mint unsuccessfully solicited the appointment of Prof. BOOTH as melter and refiner in 1838 and '40, but in 1849 Prof. BOOTH was appointed by President Zachary Taylor, and continued in the same position until his resignation in 1887, which was made necessary by the infirmities of advancing years.

Soon after Prof. BOOTH took charge of the Melting Department, the enormous influx of gold from California taxed the resources of the parent mint in Philadelphia to its utmost capacity, and necessitated a reorganization of the former business methods.

Prof. BOOTH proved equal to the emergency and devised methods of meeting the unexpected demands upon his department.

The present form of wind furnace used in melting gold and silver was mainly his design. The improvement over older furnaces consisting in the sliding doors and in the interior configuration which made his furnaces better adapted to the work than those of previous melters and refiners.

The mathematical formulæ for quickly making up the melts for coin ingots of standard fineness from miscellaneous deposits varying greatly in weight and fineness were worked out by Prof. BOOTH, and greatly facilitated the routine of business. After the decline of the production of gold, the discoveries of silver in Colorado and other Western states and territories followed, and notwithstanding the establishment of branch mints and assay offices in the West for the receipt of bullion, the bulk of the precious metal found its way to the Philadelphia Mint. The return to specie payments and the passage of the "Bland Silver Bill" in 1878 again resulted in an enormous and sudden demand upon the Mint, so that of late years the value of the precious metals operated upon in the melting department has averaged more than \$50,000,000 per annum.

This brief statement will suffice to show the vast responsibility resting upon Prof. BOOTH, and the mental anxiety consequent thereupon, coupled with earnest desire to faithfully perform the onerous duties devolving upon him, was the immediate cause of his long illness which prompted him to tender his resignation some months before his decease, to take effect upon the appointment of a successor.

Prof. BOOTH was a gentleman of courteous manner, genial presence and of singular modesty. As a public officer he was a shining example in these respects, and the fact that throughout all of the political changes of administration he retained his highly responsible position for nearly forty years, and this with eminent satisfaction to all, is alike creditable to himself and to the Government.

S. LLOYD WIEGAND, *Chairman*,
ALEX. E. OUTERBRIDGE, JR.,
CHARLES M. CRESSON, M.D.

PHILADELPHIA, April 17, 1888.

RACHEL L. BODLEY.

By the death of Prof. RACHEL L. BODLEY, M.D., the FRANKLIN INSTITUTE JOURNAL has lost the first on the list and among the most highly valued of its collaborators. Miss BODLEY lived at an

important epoch in the history of the evolution of woman's equal rights, and filled an important post in the transition stage of this question. It is not intended at this time to do more than pay the well-deserved tribute of a publicly-expressed regret to the memory of one who, while so essentially a woman, was at the same time a leader in that obviously just movement which has for its goal equal rights, equal privileges, equal facilities for learning and practicing trades and professions, and equal pay for man and for woman. It is unfortunate that the great victory for justice and magnanimity achieved in the Philadelphia County Medical Society, by the election for the first time of a woman to its membership, came but a few days too late to cheer RACHEL BODLEY, with the first symptom of a change which she, by her spotless life and earnest work, has done much to bring about. It is not the Claflins and the shriekers who can be credited with the advance of woman towards the great office that she is ultimately destined to fill, but the pure, the industrious, and the pertinacious workers who know enough of the inertia of ignorance, of prejudice and of injustice in the world to bide their time, to let the confining bark of error burst from the swelling sap within, rather than hew it off by violence. It is an instance of how much more dignified patience can accomplish than petulant complaint, that RACHEL BODLEY, who never menaced society with the consequences of neglecting her political rights, was elected one of the vice-presidents of the great convention of chemists, assembled in 1874, at the grave of Priestley, in Northumberland, Pa., while many of her sisters, who strove zealously, but not wisely, for lesser honors, failed to reach them. That they may succeed, and that before long, is the earnest hope of the writer. Their success will be the most fitting monument to the noble women who knew how to strive for a great and righteous cause ; among whom none better deserved this loving remembrance than RACHEL L. BODLEY.

PERSIFOR FRAZER.

REPORTS OF THE COMMITTEE ON SCIENCE AND THE ARTS.

THE HYATT PURE WATER SYSTEM.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 1, 1887.

The Committee of the Chemical Section, acting as a Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

"THE HYATT PURE WATER SYSTEM,"

Report as follows: In our opinion, a pure water supply is a matter of the greatest importance, and any useful device which has this for its object, not only demands the attention of the INSTITUTE, but, if it accomplishes its design, should also receive such encouragement and support as can be furnished through the recommendation of the FRANKLIN INSTITUTE.

Through the kindness of authorized agents, one of the filters of the Hyatt Company was erected in the Hall of the INSTITUTE, where it satisfactorily performed its work in the presence of the Committee.

This system, invented and patented by Mr. Isaiah Smith Hyatt, of Morristown, N. J., has for its object the clarifying and purifying of water by first coagulating the impurities and afterwards filtering it.

It will be noticed that the invention is founded upon two distinct principles; for it is well known that the purification of water, by filtration only, has proved to be impracticable on a large scale.

The extremely fine silt held in suspension in natural water cannot be retained by any filter where large volumes are operated upon. To overcome this difficulty, Mr. Hyatt's invention is directed.

The filter is simply a body of ordinary sea-sand, supported on a perforated false bottom, the whole being enclosed in a wrought-iron cylindrical vessel.

The size of the filter is in proportion to the quantity of water handled. The smallest size on the company's schedule is ten (10) inches in diameter by three (3) feet high, capacity being two

thousand (2,000) gallons per twenty-four (24) hours; the largest size is ten (10) feet in diameter, thirteen (13) feet high, capacity three hundred and twenty-five thousand (325,000) gallons per twenty-four (24) hours. The above represents one filter only (in each case), but any number can be connected and run as one.

The announcement of the company contemplates the purification of the water supplies of cities.

The filter is connected with the supply pipe in such a manner that a by-pass is formed around the filter; or, in other words, it is so arranged that the filter may be disconnected without disturbing the flow of water through the main pipe.

A small portion of the muddy water to be treated, not more than a fraction of one per cent. of the total volume, goes through an attachment to the main filter, containing lumps of alum. A minute amount of alum is thus dissolved and passes into the filter, where it is mixed with the main body of water; the quantity of alum used being less than one grain per gallon of water. The suspended clay and other earthy matter which is of a basic nature, has the effect of precipitating the alumina of the alum, causing it to separate all through the water in the form of gelatinous flocks. These minute particles bring together or coagulate the finely suspended matter, converting it into such a form that the filter will easily and completely remove it. The supply of water to this coagulator is governed by a valve regulated by a scale, each division of which corresponds to a given quantity of alum dissolved. In consequence of this action, the minute amount of alum employed is entirely destroyed, as such, and is removed from solution, the fine silt which could not otherwise be removed by filtration is converted into such a form as to be easily removable, and the resulting filtered water is perfectly bright and clear, no matter how dirty or muddy it may have been previously.

For the purpose of cleaning the filter bed, provision is made by which the current of water can be reversed, and the accumulation of dirt, etc., is removed through a special discharge pipe. The following prominent features of this system present themselves:

- (1) The ease with which the filter is cleaned, it requiring only a few minutes, and involving no extra manipulation or disturbing of the filtering material, but simply the opening of certain valves.
- (2) The rapidity with which the filter works, for with filters

destitute of a coagulating substance, the operation depends upon the closeness of the particles of the filter bed, and the water passes through very slowly. In the Hyatt filter, the water runs through in a large stream, the bright clear water running out producing a marked contrast with the dirty water entering the apparatus.

(3) The ingenious method adopted to coagulate the impurities, which plays an important part in the operation of the filter, and the decomposition of the alum, which is introduced in such infinitesimal quantities, forming a compound which remains on the filter and which, if it should, by any accident, be mechanically carried through the filter, would be without any effect upon the water. Certain chemical analyses, however, indicate that weighable quantities of the body formed (which is the hydrate of alumina) are not so carried over.

(4) The success of the filter, as proved by the favorable reports we have received from paper manufacturers and those using the filter for domestic purposes, who have, after constant use for a period of three (3) years or more, been convinced that these filters answer admirably the design of their invention.

(5.) The adaptability of this system to the purification of the water supply of cities; and,

WHEREAS, We are convinced by the above considerations, as well as by the theory of the system, of the utility of the same, we respectfully recommend that Isaiah Smith Hyatt be awarded "THE JOHN SCOTT LEGACY PREMIUM AND MEDAL," for this ingenious and practical invention.

H. WILEY THOMAS,

H. PEMBERTON, JR.,

E. H. KEISER.

Adopted January 4, 1888.

WM D. MARKS, *Chairman.*

I certify that the above is a true copy from the records.

WM. H. WAHL, *Secretary.*

CLAMER'S PROCESS OF CLEANSING AND COATING METAL SURFACES.

[No. 1385.]

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, March 1, 1888.

The Committee on Science and the Arts, constituted by the

FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

"THE AJAX METAL COMPANY'S PROCESS OF CLEANSING, PREPARING AND COATING METAL SURFACES,"

Respectfully reports : that the process in question is the subject of letters-patent of the United States granted to Francis J. Clamer, of Philadelphia, as follows :

No. 283,077, dated August 14, 1883, for a process of treating lead to impart to it the property of adhering to other metals ; and No. 363,593, dated May 24, 1887, for a process of cleansing, preparing and coating metal plates and other metal surfaces. Concisely stated, the object which Mr. Clamer has sought to accomplish in the two inventions above named, is to treat iron and steel articles by a process of chemical cleansing which shall remove all oxide and other impurities from the surfaces of the same, leaving these surfaces in such a condition as to adapt them to receive most readily a firmly adherent and smooth coating of lead. As important to the successful operation of the process, the inventor claims that the addition of slight quantities, not exceeding a small fraction of one per cent., of arsenic and phosphorus, imparts to the lead certain qualities which adapt it to yield a better and smoother coating than it is possible to obtain by other methods in use.

The process of preparing the metal for the coating is substantially as follows :

The articles of wrought or cast iron or steel are first pickled in the usual way by immersing them in a bath of dilute sulphuric acid, kept heated by the aid of a steam coil. They are then rinsed thoroughly in fresh water to remove the adhering acid. The articles are then removed and immersed in a cleansing bath of cyanide of potassium. An electric current, generated by a dynamo-electric machine (such as is commonly used in electroplating), is made to pass through this bath, the aforesaid articles being suspended therein, so that they shall form the anode of the circuit, any equivalent metallic surface being introduced at the cathode.

After an immersion in the cyanide bath for a varying length of time, from ten (10) minutes to half an hour, according to the character and quality of the products to be cleansed, the

articles are removed and given a dipping in a bath of chloride of zinc; they are then ready for the coating. For this purpose, they are introduced into a bath of molten lead, previously prepared by the addition of phosphorus and arsenic, as above described, and are kept beneath the surface of the molten metal until a uniform and otherwise satisfactory coating of metal is obtained. This operation will require from five to fifteen minutes. From the metal bath the articles are quenched in a vessel of oil, and finally dried in sawdust.

The essential novelty of this process, in which it differs from current practice, consists in submitting the articles to electrolytic treatment in a solution of cyanide of potassium to insure the more perfect cleansing of their surfaces. The more perfectly this preliminary cleansing, the more uniform and adherent will be the subsequent coating of metal, other things being equal. The extremely effective cleansing action of the cyanide of potassium has long been known and utilized in the art of electro-plating, in which, however, it is employed by simple immersion therein of the article to be cleansed. By Mr. Clamer's procedure, this cleansing action is distinctly reinforced by the aid of the electric current.

As an improvement in the current practice of cleansing metals to receive a deposit of another metal by immersion, as in tinning, galvanizing and leading, the method of Mr. Clamer is worthy of commendation.

The Committee has had the opportunity of witnessing the entire process in operation, and of examining the finished products. The latter, so far as appearances can be relied upon to form a judgment of their quality, were all that could be desired. The coating is smooth, lustrous and adherent both upon cast and wrought iron.

To what extent the quality of the coating may be due to, or influenced by, the presence of the phosphorus and arsenic added to the lead, the Committee is not prepared to express any decided opinion. It is highly probable that these additions may promote the formation of an adherent and smooth coating by their disposition to increase the fluidity of the molten metal. It is well known that it is difficult to secure a satisfactory coating of lead upon iron without notable additions of tin, a much more costly metal. It is probable, therefore, in view of this fact, that the

greater cost involved in the preliminary cleansing operation employed by Mr. Clamer may be offset by the fact that he is able to dispense with the addition of tin to his metal. As to the quality of his product, this is, beyond question, excellent.

The Committee commends Mr. Clamer's inventions as meritorious.

J. H. EASTWICK,
CHAS. A. RUTTER,

WM. H. WAHL,
S. LLOYD WIEGAND.

Adopted April 4, 1888.

GEO. A. KOENIG, *Chairman.*

I certify the above is a true copy from the records.

WM. H. WAHL, *Secretary.*

BOOK NOTICES

PRACTICAL HINTS FOR DRAUGHTSMEN. By Charles William MacCord, A. M., Sc. D. New York: John Wiley & Sons.

This work is intended to explain practical methods as distinguished from the precise ones of projection, and claims that "*mechanical drawings often convey false impressions by too close adherence to the truth and become obscure by being too exact.*" How well this is illustrated will appear later.

There is originality in the theme, terseness in the language, clearness in the explanations, and a positive, convincing style of expression, well calculated to impress the novice and to start the young B. E. upon methods, many of which would surely lead to mistakes and loss.

Admiring, as we do, the former work of the author and having long recommended it as the best obtainable guide, we trust that the following criticism of this latest production will be carefully considered by him as the conscientious opinion of one who has had long practical experience under favorable and varied conditions, and we hope that, having looked well into the matter of common practice, the author will correct the errors which we feel sure he has been led into, or made inadvertently, and will, with his happy method of expression, give us what is so much needed, a book, correct in detail and embodying the application of principles to actual work.

CHAPTER I contains definitions and rules with illustrative examples. The supposed Code of Laws given in paragraph 7 will not all be admitted as such by any good draughtsman, while the general principles enunciated in paragraph 8 will be accepted as excellent, but an examination of the practical applications of these principles will immediately expose the fallacy of the motive of the chapter. The positive statement that: "*it is amply proved by experience that drawings may be absolutely correct and fail, nevertheless, to show the workman what to make and how to make it,*" is misleading and mischievous, and is unsustained by any of the examples given.

Under Example I, the statement that "*the continuity of masses of metal should not be broken for the purpose of showing fastenings,*" is the key-note of

an erroneous principle which runs through the whole of this chapter, and it would be difficult to compose another sentence so short yet containing so much bad advice. The workman's business is with the fastenings and they are the very things about which he wants definite and clear information. Under the same example, the maxim "*that each view should be made to tell all it can*" (without distortion), "*but nothing should be put in which does not tell something worth knowing*," is excellent, with the above parenthesis inserted, but is violated by *Fig. 1*, which is given to illustrate it. In this figure the top view shows seven bolt holes from which the bolts have been properly omitted, while the vertical section does not tell positively that one bolt is in the central plane, and does show another bolt out of its position, which is not worth knowing.

In Example II the general rule that "*a web parallel to the paper should not be shown in section*," should be taken *cum grano salis*; that is to say, the rule should be the opposite, but occasional exceptions permitted when dictated by very good judgment. *Fig. 3*, given to illustrate the merits of this rule, is the first of a series of incorrect drawings, the only results of which would be doubt, uncertainty and perhaps mistakes.

The so-called maxim in Example IV, that "*if a thing be symmetrical, it should be represented as symmetrical in every view if possible*," is erroneous, because the details which are odd or out of symmetry are the very ones worth knowing and about which the information should be clear and definite. In *Fig. 5* the section through the pulley should stop at the key, thus bringing the latter into prominence and emphasizing the fact that the pulley is to be keyed to the shaft. If the key was headless and the length of the hub (the usual practice) the greater clearness of correct drawing would be more apparent.

In Example VI, the rule "*the fillet lines should be drawn in outside views of surfaces of revolution*," is a bad one, illustrated by numerous examples of faulty drawing, the worst of which is *Fig. 10*, in which the joint between a collar pinned on a shaft and a rotating piece on the same shaft happens to coincide with the fillet line, necessitating the objectionable practice of sectioning over an outside view, in order to prevent the two pieces from being mistaken for one. This practice is actually recommended in Example VIII, and illustrated by *Fig. 9*, which would better serve as a warning for its avoidance.

There is, in Example VII, an adage which can be heartily recommended, viz: "*Judicious omission is preferable to correct superfluity*." Unfortunately, *Fig. 8* does not illustrate this with any force, inasmuch as there is no gain in omitting the cap from the *plan*. In this figure the *plan* is placed *under* the elevation, while in other figures it is placed *above*, showing no positive system. Although the use of the third angle in making projections is far more sensible, convenient and clear than the first, still there is no vital objection to the use of the first if it is in all cases strictly adhered to, but a mixture of the two is sure to lead to mistakes in the shop.

Inasmuch as we have been in the habit of quoting the author as one who has advocated strongly the "common sense method of drawing" in which the third angle is used, we feel disappointed to note the disregard of this in many of his examples.

There is no merit whatever in the point made in Example X that, "*thus the true dimensions are seen in both views,*" which is illustrated by *Fig. 11*.

On the contrary, if the drawing was complicated and not merely the simple detail which it is, the suggested variation from the truth would be extremely confusing, and, in the present instance, it does far more harm than good.

The*most inexcusable case of bad drawing is in Example XII, *Fig. 13*. The impression given by the section is that the gland is held by four stud-bolts, and this we have verified by submitting the drawing, with the top view concealed, to several pattern-makers and experts. When, however, the top view is seen, the mind is in doubt as to what is meant by such a distortion for no useful purpose. A pattern-maker would waste much time in worry and inquiry before commencing work from such a drawing.

Without going further into an analysis of the details of this chapter, we feel convinced that, if an establishment employing a large number of draughtsmen should permit each individual to devise inaccurate and inexact methods of drawing, based upon the hints given in this chapter, trouble, loss of time and confusion would result. And besides, we feel constrained to say that, looked at from our standpoint, each deviation from accurate methods or well-established conventionalities has diminished both the clearness and force instead of increasing them.

Chapter II, on the REPRESENTATION OF BOLTS, ETC., is, in many respects, as erroneous as the preceding. Good taste and sound judgment dictate that the outside face of nuts should be chamfered, both for the sake of appearance and to prevent the edges from becoming battered up by the use of the wrench. There is no necessity to chamfer the bearing face also, because all bolt holes should be faced. In cases where the surface, against which the nut bears, is polished, it is the custom of some shops to turn off an additional shaving (say one hundredth of an inch) from the corners parallel with the face, to prevent the risk of these corners marking the polished surface. This is good practice and is cheaply done. Jamb nuts only are chamfered on both faces in order to protect their edges.

It is a mistake to make a different standard for the sizes of bolt heads from that for nuts, because both through bolts and tap bolts are frequently used in the same piece and on the same surface, where appearance, convenience and every consideration would require that the bolt heads and nuts should be of the same size.

Chapter III, on FREE-HAND SKETCHING, is the best portion of the book.

Chapter IV, on INSTRUMENTS, in many particulars shows want of familiarity with good practice. The implied disparagement of the Alteneder instruments is unjust, particularly as every piece that Alteneder makes is the superior of those described in the book. The old triangular scale, with twelve different scales on one piece of boxwood and with the subdivisions into inches and fractions made only in the first foot or unit of each, is minutely described and elaborated. This is the scale which every apprentice starts out with and abandons as soon as he gets down to real business. Still, on the whole, this chapter gives information, much of which is useful, on points which are not to be found in print.

Taking the book as a whole, its literary merits, ingenious arguments and epigrammatic assertions should not be permitted to cause its acceptance as an authoritative guide.

W. H. THORNE.

COLLECTION DES ANCIENS ALCHEMISTES GRECS.—Par M. Berthelot, Membre de l'Institut, avec la Collaboration de M. Ch. Em. Ruelle. Première Livraison. xxiv, 268 et 115 pp. 4to. Paris. Gouvernement, 1888.

This first part of a publication, whose contemplated length is extended, includes an introduction by M. Berthelot, a Greek text with variations and philological notes by M. Ruelle, Librarian of the Bibliothèque St. Geneviève of Paris, a translation of the same by the two authors, and with notes and comments by M. Berthelot. It is an exhaustive study of Greek manuscripts belonging to Leiden and to Venice, the latter having been loaned to M. Berthelot two years by the Italian government. The Greek text was copied by M. Ruelle from MS. 299 of St. Mark's Library, dating back to the tenth century, No. 2,327 of the Bibliothèque Nationale of Paris, which is of the fifteenth century, and twelve later manuscripts. The largest of the latter is No. 2,419, and is written under the name Theoctonicus; it is unquestionably of the same authorship as the later Latin alchemy, attributed to Alberto Magnus.

The introduction of 268 pages opens with a history and description of the Papyrus X of Leiden, the actual date of which is in the third century of our era, but whose contents must have been brought down from a much more remote epoch. It is one of the works of Egyptian alchemy that escaped the general destruction of Eastern literature undertaken by Diocletian toward 290. It proves the Egyptian origin of alchemy and of the ideas of transmutation of metals. These ideas do not appear to have arisen in philosophical dreams, but to have been the outcome of trade tricks of Egyptian goldsmiths.

The Leiden Papyrus, more especially devoted to chemistry, is composed of ten leaves, 0.30 x 0.34 metre, comprising sixteen pages of writing in capital letters of the end of the third century. It bears evidence of being the work-room note-book of a tricky goldsmith and charlatan magician, and was probably preserved in a tomb or mummy of Thebes. By this accident it escaped the Roman destruction and the mutilations of Fellah curiosity merchants. Its great resemblance, almost identity, with later Greek alchemists, shows the sources used by the latter. A Latin translation of this MS. has been published in two 4to volumes by Leemans, of Leiden.

The text is a mixture of astute receipts, charlatanism, gnosticism and Egyptian, Jewish and Pagan mysticism, and indicates that the first notions of alchemy did not originate in chimerical imaginings, but in positive practices and real experiments for the imitation of gold and silver—sometimes purely for the deceit of the public and without self-illusion, sometimes with the addition of magic formulae and prayers that rendered the author the dupe of his own work.

The recipes include seventy-five formulae of metallurgy; the composition of alloys for making cups, vases and images; for soldering and artificially coloring the surface of metals, and for testing their purity. These recipes follow one another without order, and with numerous repetitions, as would be the case in the note-book of a goldsmith working sometimes with pure

metals, sometimes with alloys and sometimes with imitations. The text is full of idioms and errors of orthography and grammar; it is the practical language of an artisan, and it bears the stamp of great sincerity, without a shade of charlatanism, notwithstanding the professional dishonesty of the recipes.

These recipes, as well as those of the other MSS. are given and commented on, and the drawings of apparatus and mystic symbols of the St. Mark's MS. are reproduced.

One curious discovery of M. Berthelot is that the accepted etymology of *cobalt* is questionable. It is generally believed that the word is of German origin, referring to the demons which were credited with the difficulties in the working of cobaltiferous ores. Cobalt blue has, however, been found in Greek and Roman antiquities and Egyptian beads, and M. Berthelot calls attention to a passage in the *Lexicon Alchemiæ Rulandi*, "*Cobationum fumus est kobolt*," and finds the same expression in a passage cited by Olympiodore in his Greek text. There has then been a probable confusion between an ancient Greek word and a German one, notwithstanding that the precise sense of the modern word cobalt is different from that of its progenitor, which referred to a sulphurous arsenical mineral.

The work is written in M. Berthelot's best style, and will be of great value to those who are interested in the study of the origins of chemistry.

W. H. G.

NOTE TO LIBRARIES AND INDIVIDUALS.—It is not generally known that the International Congress of Geologists invites the membership not only of those individuals who can attend, and of those who cannot attend the sessions next September, but also of *societies, libraries* and *institutions*, which of course cannot be looked upon as geologists. The object it has in view is one of equal benefit to the Congress and to the individuals and institutions. The former desires the widest possible circulation of its work, and for a price absurdly disproportionate to the value of the documents received, each subscriber can receive the published proceedings of the Congress containing the latest summaries of the broadest questions by the international and national committees, and a goodly list of special publications prepared by different persons and societies for distribution at the Congress and generally printed in the editions which are regulated by the number of subscriptions to the Congress. These documents embody the latest researches on their various subjects and are not procurable otherwise than by this distribution. Add to this that in the recorded debates and discussions which the proceedings contain, one is made aware of the light in which the best minds view the several subjects treated. The volumes of previous Congresses (Paris and Bologna) are almost out of print and hard to secure at two or three times the cost of "matriculation" or "cotisation" (as the French call it), while the documents which were distributed to the members of those Congresses are unattainable.

If ten shillings be sent to Mr. Wm. Topley, General Secretary of the Committee on Organization of the Congress, Geological Museum, 28 Jermyn Street, London, together with the name of the person or institution desiring to become a subscribing member of the Congress, all these documents will be sent to the said subscriber free.

P. F.

(Dimensions in Millimetres.)

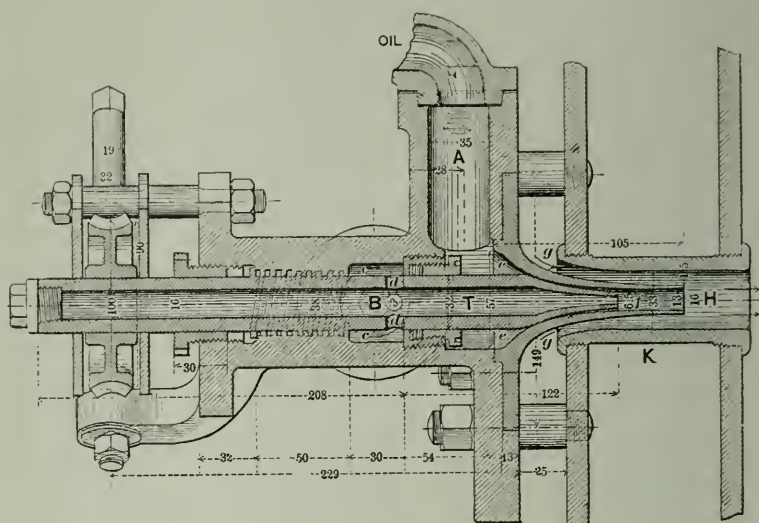


FIG. 1. The Urquhart Oil-Fuel Injector.

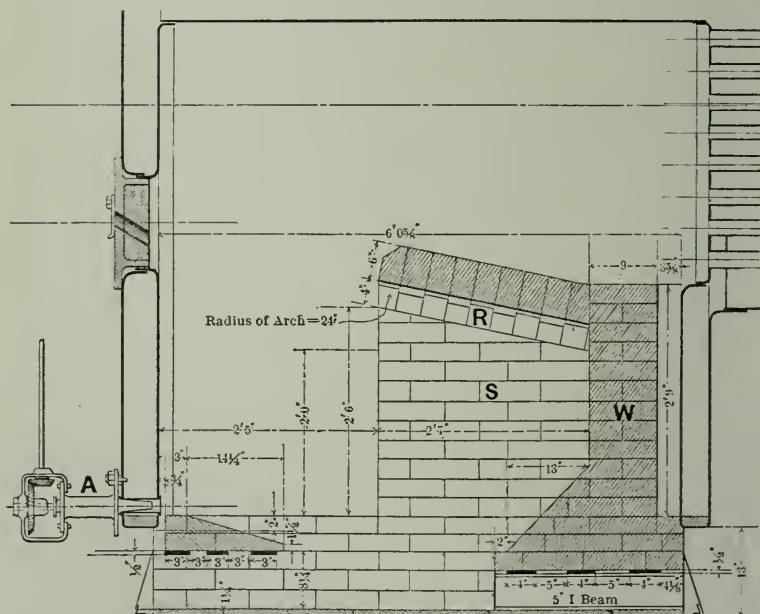
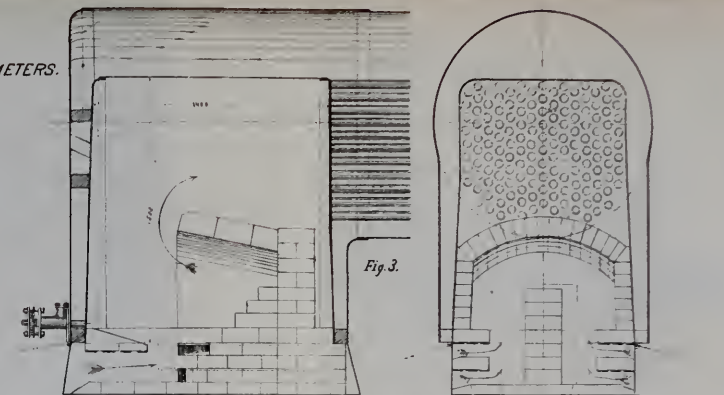
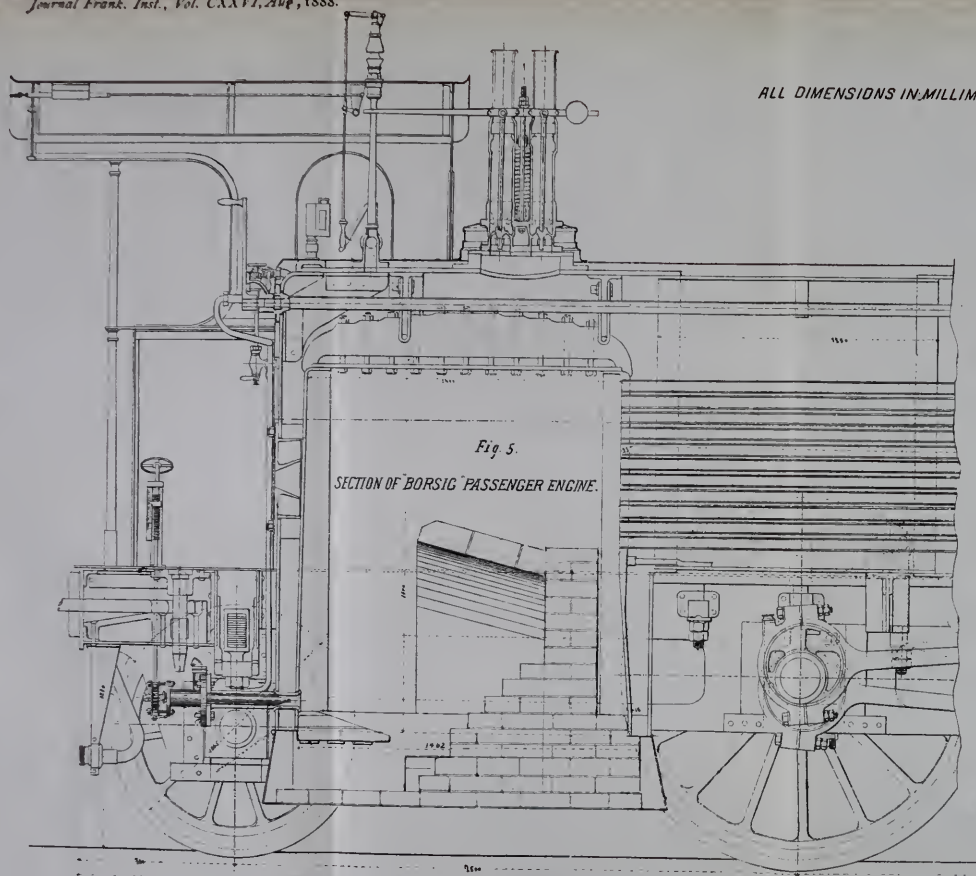


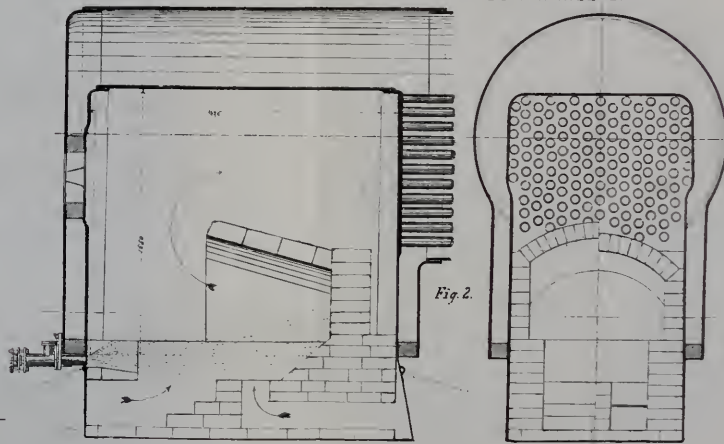
FIG. 4. Petroleum-burning Furnace, Pennsylvania Railroad Experiments.

ALL DIMENSIONS IN MILLIMETERS.

Fig 5.
SECTION OF "BORSIG" PASSENGER ENGINE.



PETROLEUM FURNACE-REAR AND SIDE AIR INLETS.



PETROLEUM FURNACE - FRONT AND REAR AIR INLETS.

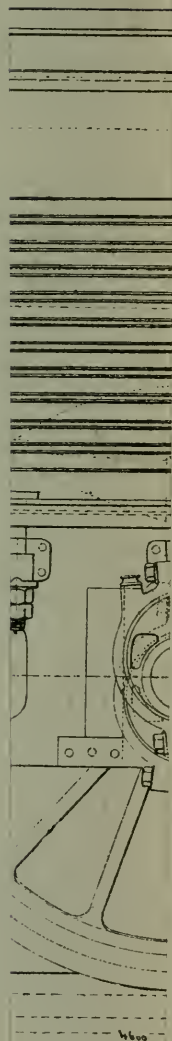


FIG.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,
FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI.

AUGUST, 1888.

No. 2.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

FUEL OIL.

BY DR. CHARLES B. DUDLEY, Chemist, Penna. R. R. Co.

[*A Lecture delivered before the FRANKLIN INSTITUTE, January 6, 1888.*]

Dr. DUDLEY was introduced by the Secretary of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

Undoubtedly almost every one who has thought on the subject at all, has wondered why it is that petroleum has not come into more general use as fuel, and the more we think of the subject abstractly, the more wonderful it seems. Here is a substance which contains no ashes whatever, every portion of which can be burned up to produce heat, and in which from its composition every pound contains more heat-producing power than any other material, which exists in large quantities and over wide areas, with

WHOLE NO. VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.)

which we are conversant, and with these advantages in its favor, there must certainly be some good reason why oil has not been used more largely as a means of heat generation. If we succeed in what we attempt this evening, we will make the matter clear to you.

But before we take hold of this part of the problem let us examine together some other phases, for besides the real and most important reason, which we will discuss later, why petroleum has not been used for fuel generally up to the present time, there are other reasons which, up to within the last few years, have been very potent in preventing the use of petroleum for fuel. The first of these difficulties is that which we are met with at the outset, namely, how shall we burn petroleum? Coal, wood, lignite, etc., are solids, and to burn them it is only necessary to ignite them on a grate and supply the necessary air to keep up combustion. Oil, on the other hand, is a liquid and will not remain on a grate, so that the first difficulty really to overcome is to devise some method of burning the oil.

Experiments have been made by different inventors, more or less during the last ten or fifteen years, having for their object to devise a successful method of burning oil. Without attempting to give a connected or accurate history of these earlier experiments, it is perhaps sufficient to say that most of the experiments made, until within the last two or three years, attempted to convert the oil into gas or vapor before trying to burn it. In other words, a preliminary treatment of the oil or preparation of the oil was relied on as an essential step in the process. The general result of all these experiments has been that the preliminary treatment method did not prove successful. The generators used to convert the oil into gas or vapor would clog up and the preliminary treatment was expensive. A good many thousand dollars have been expended on these experiments, simply to learn that in order to burn petroleum successfully some method must be devised which takes the oil as it comes. Now, we know that previous preparation is entirely unnecessary, and that petroleum can be burned with perfect success and with almost complete consumption of the oil without any preliminary preparation or treatment.

It is perhaps difficult to say who first struck the essential feature of successful petroleum burning, but it is fairly safe to say that

Mr. Thomas Urquhart, of Borisoglebsk, Russia, Locomotive Superintendent of the Grazi-Tsaritzin Railway, made the first successful attempt on a large scale to use petroleum as fuel. Mr. Urquhart is a Scotchman by birth, and has been some nineteen years now in Russia, and when I visited him in October, 1886, he had some 143 locomotives in daily use burning nothing but petroleum, as well as a large number of stationary boilers, pumping engines, machine shop engines, etc. Indeed, the whole Grazi-Tsaritzin Railway uses almost nothing but petroleum for heat generation. The essential features of Mr. Urquhart's system of petroleum burning may be perhaps briefly described as follows: (1) The burner which converts the oil into a spray or very finely-divided condition; (2) the location of the burner in such a position in regard to the fire that it never becomes hot, and consequently never clogs; (3) the location within the fire-box of a mass of fire-brick so arranged as to form a combustion chamber and to serve as radiating points for the heat, and also to serve to a certain extent as a storage for heat. The fire-brick arrangement still further has the additional advantage of breaking up any particles of oil which escape from the burner unpulverized, so to speak, and also of re-igniting the oil after it has been shut off for any time, as when stopping at stations.

Let us examine these three features a little in detail by means of the diagrams on the screen, here shown in *Figs. 1, 2, 3, 4* and *5*.

(1) The burner. It will be observed that the burner is essentially two tubes. The inside one of these tubes carries steam taken from the boiler. The outside one contains oil taken from the reservoir on the tank. The burner is located as seen in *Fig. 2*, well down in the back leg of the fire-box just above the ash-pan. A thimble *H*, shown in *Fig. 1*, through the back leg of the fire-box forms the communication between the burner and the inside of the fire-box. The burner is supported on the back fire-box sheet by bolts, and stands about an inch away from this sheet. As will be observed, the inside tube, which carries the steam, forms a fit against the inside of the outside tube, and prevents the oil from passing through what may be called the combining tube, until it is desired to have it do so. The worm-gear on the back end of the burner, which is operated from the cab, serves to withdraw the inside tube and allow the oil to pass.

The operation of the burner is as follows: The cock on the pipe connecting the boiler to the inside tube being opened to pretty nearly its full extent, steam enters the annular recess, *cc*, and from it through the holes, *dd*, passes through the inside tube *T* and rushes into the fire-box. Now, by operating the worm-gear by the hand-wheel, shown in *Fig. 5*, this inside tube is drawn back and the oil allowed to flow in. When it reaches the end of the inside tube, it is caught by the steam and practically atomized, or converted into a fine state of division, the mixed spray, so to speak, being projected into the fire-box, as shown in *Fig. 2*. A bit of ignited oily waste on the end of a rod being stuck down through what was originally the fire-door, and which has been closed up with brick-work, except a small hole, ignites the stream of atomized particles, and the heat generation begins. As will be observed, the burner is exceedingly simple in construction. It takes the oil just as it receives it, and projects it into the fire-box in condition to be rapidly and completely consumed.

(2) The location of the burner. It will be observed that the nose of the burner does not reach into the fire-box. It is about an inch, or so, back in the thimble from the fire-box side, and in this condition never gets hot enough to decompose the oil, consequently no carbon is ever deposited and the burner never clogs.

(3) The fire-brick arrangement. The fire-brick arrangement may, perhaps, best be described as a sort of bonnet, with the open end of the bonnet toward the rear end of the fire-box. The bottom is more or less open for the admission of air. The back of the bonnet serves, as has already been stated, to receive any drops of oil that may escape being atomized in the burner and breaks them up by the rebound in condition to be burned. The bonnet itself is a sort of combustion chamber. After a good deal of experimentation, two methods of admitting the air were decided upon, both of which give excellent results. These two methods are shown in *Figs. 2* and *3*. In *Fig. 2*, the air is taken in at both front and rear. In *Fig. 3*, the air is taken in at the rear and the sides. Very little difference is noticeable in these two methods. Some forms of locomotive construction lend themselves better to one and some to the other. The small ledge shown just inside the fire-box, near the end of the burner, prevents dropping down of the oil, and also serves as a help in maintaining combustion.

Fig. 5 shows the general arrangement on a standard passenger engine on the Grazi-Tsaritzin Railway.

With above description and cuts it is perhaps not difficult to see why this method of burning petroleum has proved to be a success. The difficulties encountered by the earlier experimenters in breaking up the oil into vapor or gas do not occur with this method. The oil is burned just as it is supplied to the locomotive, with no other preparation than converting it into a finely-divided state. The burner is so located that it cannot clog, and if perhaps a stick or bit of dirt gets in the passage between the inner and outer tubes, it is only necessary to draw the inner tube back a little further, and allow it to pass into the fire-box along with a *douce* of oil, which produces no results other than a momentary out-puff of black smoke from the smoke stack. As has already been described, likewise the brick-work, which in operation becomes actually white hot, serves a very important purpose in this scheme, and although it cannot be regarded as absolutely essential, since there are systems of burning petroleum in successful use which do without the brick-work, it is unquestioned that much more uniform and reliable results are obtained with the brick-work than without it. The brick-work, well put up of good fire-brick, will last from six to eight months, but poor brick will not stand the intense heat.

It will be noticed that steam pressure has been previously described as essential in starting the fire. Air pressure may, of course, be used in place of steam, both in working the locomotive continuously and in starting up, and a number of experiments have been made with air to determine which was the more economical. No special advantages in favor of air have thus far been shown. When a locomotive is cold, it is customary on the Grazi-Tsaritzin Railway either to connect with the burner, by appliances for the purpose, a shifting engine already in steam, or when the engine is in the round house, connection is made with appliances arranged for the purpose from a stationary boiler. It takes from fifteen to twenty-five minutes with a cold engine to get up thirty to forty pounds pressure in a locomotive boiler, and when this pressure is once obtained, the engine will take care of itself.

There are two other systems of burning petroleum, one of which at least is in quite general use in southeastern Russia, namely, the Lentz system. This system is used a good deal on the

Volga steamers. It depends for its success apparently on the same principles that have already been described, namely, it converts the oil into a finely-divided state by means of steam, and burns this mixture of spray and steam. We believe there is no brick-work required, the material being simply projected into the fire-box. In this country, the Edwards oil burner has been used with considerable success, and this likewise converts the oil into a spray, doing it in a little different way, however, than the method used by Mr. Urquhart. We have seen likewise simply two pieces of tube, one inside the other, and with the control of the steam and oil by means of globe valves, the mixed steam and oil being simply projected into an ordinary fire-box. This is used on stationary boilers.

In the winter and spring of 1886 and 1887, experiments with the Urquhart system of burning petroleum were tried on the Pennsylvania Railroad. The devices used were practically the same as those used by Mr. Urquhart, but some little modification was needed. Locomotives in America are worked much harder than they are in Russia, and it was found essential to enlarge the burner a little, also the space for taking in air was found to be insufficient to prevent smoking, and the appliances for controlling the feed, which are operated from the cab, do not give quite as rapid movement as was deemed essential with the harder working engines of the Pennsylvania Railroad. The arrangements made use of on the Pennsylvania Railroad are shown in *Fig. 4*, which, as will be observed, are the same in principle, but with the modifications already described. *W*, is a fire-brick wall at the front end of the fire-box, with sides *S*, and an arch *R* on top. The air was taken in at the front and rear, the middle partition shown in *Fig. 2* being completely dispensed with, so as to allow the amount of air necessary to consume the oil. In place of the worm gear, likewise, for controlling the feed, a bevel gear acting more rapidly was used.

A single burner of the kind already described has been found to be abundantly sufficient to furnish all the steam required by an ordinary locomotive. The firing on oil-burning locomotives is simply ideal. The fireman sits on his box, or, as in Russia, stands at the wheel, with his attention fixed on the steam gauge and the smoke stack. He catches a glimpse of black smoke at the smoke stack; a slight turn of the wheel diminishes the supply of oil and

the smoke disappears. The engineer shuts off steam on arriving at a station. Instantly the supply of oil is shut off and the steam gauge scarcely changes a point. There is the most perfect relation between the violence of the exhaust, which means the amount of air pulled through the fire-box, and the supply of oil furnished. So perfect is this adjustment that it is not at all rare to see an engine, in which everything is working with perfect satisfaction, begin to smoke from a slight change in the relations between the exhaust and the supply of oil. So slight a change as the movement of the reverse lever one notch, which means a little less steam going through the exhaust, which means a little less violent draught, which likewise means a little less air drawn into the fire-box, will cause smoke to appear at the smoke stack. Of course this is entirely under control, and it is the fireman's duty to see that the steam pressure is kept up without smoke. Mr. Urquhart instructs his engineers to run on what he calls the "gray smoke," so as to be sure he is not drawing an excess of cold air through his fire-box. The gray smoke may be best described as the small line left after the steam has disappeared to mark the passage of a train on a clear day. Only those who are accustomed to it can detect the little smoke in the presence of the steam as it leaves the smoke stack. The comfort to the passengers by the use of this magnificent combustible for generating steam, can hardly be described. Not a cinder or a trace of smoke ever disturbs them. Windows can be left wide open, so far as the locomotive is concerned.

It is, perhaps, entirely safe to say, in view of what is actually being done, both on the Grazi-Tsaritzin Railway, on the Volga steamers and on the Trans-Caucasian Railroad in Russia, and also the experiments that have been made in this country to a greater or less extent, and in view of the description given above, that oil burning, so far as it depends on a method of doing the burning, is a success, and that this part of the problem is solved. Let us now turn our attention to some other phases of the problem. The practical part of the problem is solved; the how-to-do-it is clear; the problem that remains is, can oil be burned as a means of generating heat with economy?

This problem may be approached in several ways. Let us look at it by comparing oil with coal. The following table shows the relative heat-producing power of coal and oil. In this table, the

following assumptions are made. A pound of anthracite coal is supposed to contain ninety per cent. carbon. A pound of bituminous coal contains eighty-five per cent. carbon and five per cent. hydrogen. A pound of oil contains eighty-six per cent. carbon and fourteen per cent. hydrogen, and the heat-producing power of the carbon and hydrogen in the theoretical part of the table are calculated by means of the well known heat units of these two substances.

RELATIVE HEAT-PRODUCING POWER OF COAL AND OIL.

	<i>Pounds Oil = Pounds Coal.</i>	
Theoretical anthracite, ...	1	1'61
" bituminous, ...	1	1'37
Urquhart's experiments, ...	1	1'756
Peninsular Car Company, ...	1	1'742
Elevated railroad, New York, ...	1	1'785

It will be observed that Mr. Urquhart's experiments, which we may say are the result of a year's experience with the same 140 locomotives using coal and using oil, show that a pound of oil will generate as much heat as one and three-fourths pounds of coal. The experiments at the Peninsular Car Company, at Detroit, Mich., were made with Canadian petroleum in October, 1885, and show, as is observed, a very close agreement with Mr. Urquhart's figure. The experiments made on the elevated railroad, in New York, were made during the summer of 1887. It is very interesting to note that experiments made in different countries, at different times and by different experimenters, should show so close a relation in the amount of heat-producing power of coal and oil, and it is perhaps safe to say in general, which is the figure that Mr. Urquhart uses mostly, that a pound of oil is as good for producing heat as one and three fourths pounds of coal.

The ratio of coal to oil having been obtained, we are in condition to begin to study the financial part of the problem, and it is clear that thus far the oil has the advantage, for every pound of it is as good as one and three-fourths pounds of coal. However, oil is usually bought by the gallon or barrel, while coal is dealt in by the pound or ton. It is plain, therefore, that in order to get a figure representing the cost of doing a certain amount of work, either by coal or by oil, we need to bring these measures together. Assuming, therefore, that a barrel of oil contains forty-two gallons,

that a gallon of oil weighs 7.3 pounds, and that 2,000 pounds is a ton of coal, we have the two following formulæ, which will enable us to compute either the price that we can afford to pay for oil per barrel, if we know the price of coal per ton, or the price of coal per ton to be equivalent to oil at a given price per barrel :

$$\frac{2,000 \text{ multiplied by the price of oil per barrel}}{\text{Weight of oil per gal. } \times \text{ by no. gals. in bbl. } \times \text{ by ratio oil to coal}} = \text{Equivalent price of coal per ton.}$$

$$\frac{\text{Weight of oil per gal. } \times \text{ by no. gals. per bbl. } \times \text{ by ratio of oil to coal } \times \text{ price of coal per ton}}{2,000} = \text{Equivalent price of oil per barrel.}$$

By the use of these formulæ, the following tables have been calculated. And here it should be stated, that in actual practice it is found that there are certain economies where oil is used in addition to the economies in fuel account, notably saving in the cost of handling fuel and ashes, and economies in repairs to locomotives, especially fire-box repairs. This gives us two tables, one in which fuel account alone is considered, and the other in which all the ascertained economies are considered. As will be described in detail later, there are certain chances for economy in burning oil that do not occur with coal. Of these there have been pretty well worked out, as just stated, economy in handling fuel and ashes, and economy in repairs to locomotives. The amount of these has been obtained in dollars and cents and is, perhaps, best expressed by saying that, taking all ascertained economies into account, a pound of petroleum is as good as two pounds of coal.

RELATIVE VALUE OF COAL AND OIL, FUEL ACCOUNT ALONE CONSIDERED.

Oil per Barrel at

\$0 20
30
40
50
60
70
80
90
1 00
1 10
1 20
1 30

Coal per Ton at

\$0 74
1 12
1 49
1 86
2 24
2 61
2 98
3 35
3 73
4 10
4 47
4 85

<i>Oil per Barrel at</i>	<i>Coal per Ton at</i>
1 40	5 22
1 50	5 59
1 60	5 97
1 70	6 34
1 80	6 71
1 90	7 08
2 00	7 45

RELATIVE VALUE OF COAL AND OIL, ALL ASCERTAINED ECONOMIES CONSIDERED.

<i>Oil per Barrel at</i>	<i>Coal per Ton at</i>
\$0 20	\$0 65
30	98
40	1 30
50	1 63
60	1 96
70	2 28
80	2 61
90	2 93
1 00	3 26
1 10	3 59
1 20	3 91
1 30	4 24
1 40	4 56
1 50	4 89
1 60	5 22
1 70	5 54
1 80	5 87
1 90	6 19
2 00	6 52

It should be remembered in making all calculations as to the relative cost of coal and oil for heat production, the two must be taken in the same situation. It would be obviously incorrect to take the price of oil as quoted in the daily papers, which means the oil in the pipe lines or in the storage tanks in the oil regions, and compare it with coal in Philadelphia, which has already been transported from the coal regions to this point. The two must be compared in the same situation, and if the ratio of one pound of oil equals two pounds of coal are considered, the prices must be compared with the fuel ready for use, either on the locomotive tender, or in the tank at the stationary boiler. The formulæ and the tables will enable everyone to make the comparison for themselves for their own locality. It will perhaps be somewhat

surprising to those who have not made some calculations on this subject, to note that oil at three cents per gallon is considerably over \$4 per ton for coal, and also to know that at present prices even crude oil at Philadelphia is difficult to be had at three cents per gallon.

Allusion has already been made to certain advantages which oil has over coal as fuel. Among these advantages the following may be enumerated.

(1) Less waste of fuel. Upon this point it should be stated that it seems probable that, with ordinarily constructed locomotives, working pretty hard and using a violent exhaust, at least as high as fifteen per cent. and possibly even twenty-five per cent. escapes combustion. There are three ways in which the fuel can escape: First, smoke and unburned gases which go out the smoke stack; second, cinders which go out the smoke stack; and, third, fuel which escapes through the grate. With oil, however, it is believed that combustion is practically complete. As said above, in oil burning a slight gray smoke is allowed to escape in practice, and it is also possible that some of the gases may escape unburned, but the loss is believed to be very much less than with coal.

(2) Economy in handling fuel.

(3) Economy in handling ashes.

(4) Diminished repairs to locomotives.

These three advantages have already been mentioned, and their money value has been obtained by experiment.

(5) Economy in cleaning engines. The absence of smoke and cinders around the locomotive when using oil is the source of this economy.

(6) Less waste of steam at the safety-valve. It is obvious that all the steam which goes out the safety-valve simply means so much fuel gone to waste, and until recently we have never known of any positive information showing how much this loss was. During the experiments made with oil on the elevated railroad in New York, it was found that it took twenty-five per cent. more water to do the same work with coal than with oil, and the explanation of this was the waste of water in the form of steam at the safety-valve. This loss on the elevated railroad is, of course, much higher than in ordinary locomotive practice, owing to the fact that the steam pressure must be kept as high as possible, that

an anthracite fire is a difficult thing to control, and that frequent stops must be made. It is probable, however, that in ordinary locomotive practice the waste of steam at the safety-valve may be as high as five per cent. and possibly more. With oil as fuel, it is possible to work for days without raising the safety-valve. During nearly a week's daily riding on the locomotives in Russia on the Grazi-Tsaritzin Railway, I only saw the safety-valve lifted once, and with proper care on the part of the fireman, there is no need of any waste of steam at the safety-valve.

(7) Economy in cleaning ballast. The cinders which are thrown out of the smoke-stack in coal-burning locomotives are a loss, not only because they are not burned, but because they fall on the track and choke up the ballast, especially where stone ballast is used. This choking of the ballast interferes with the drainage, and the result is every year thousands of dollars have to be spent in cleaning the cinders out of the ballast. It is difficult to say how much of a saving would be effected if oil alone was used, with consequently no cinders, but it is safe to say that it would amount to a good many thousand dollars on stone-ballast roads in a year.

(8) Economy of space in carrying and stowing fuel. A pound of oil does not occupy as much space as a pound of coal, and consequently a sufficient amount of oil to furnish a certain amount of heat could be carried in a smaller space than coal. This is of great importance on steamers, and of course not of relatively so great importance in locomotive practice.

(9) No fires from sparks. Oil burning being practically free from smoke and cinders, there are no buildings or other property destroyed along the track. How serious a difficulty this is with coal-burning roads it would take an examination of the damage account to show, but it is safe to say that it is not small.

(10) No smoke and cinders. It is difficult to put into money the advantages arising from the absence of smoke and cinders, but we will venture the assertion that the railroad that first adopts oil will distance its competitors in its passenger traffic, owing to the absence of smoke and cinders.

(11) Possibility of utilizing more of the heat. It may be, perhaps, not generally known that the size of the flues in an ordinary locomotive are decided upon by the ability of being able to keep

them from becoming choked up with cinders. A small flue is readily choked with cinders in coal-burning locomotives. On the other hand, the smaller the flue the more heating surface it is possible to obtain in the boiler, and the greater relative advantage is obtained from the fuel actually burned. If locomotives were constructed for oil burning, it would probably be easy to use flues one inch in diameter, instead of one and three-fourths or two inches as at present, with consequent ability to utilize more of the heat generated than is now done.

One or two points further very briefly. What kind of oil should be used? There are three reasons why crude oil should not be used, especially on locomotives, namely, it is more dangerous, it has an exceedingly unpleasant odor, and it is not so economical. As is well known, crude oil contains more or less gaseous matter, and also vaporizes quite readily. With the necessary use of lanterns and open lights around locomotives, there would consequently be more or less danger of explosions. Furthermore, in case of a wreck if the oil tank was ruptured, it would be almost impossible to prevent a fire. The odor of the crude oil need not be specially mentioned, further than to say that it would certainly be extremely unpleasant to ride behind a locomotive fed with Lima crude oil. The reason why crude oil is not so economical as reduced oil is because oil is usually sold by volume, and a gallon of crude oil instead of weighing, as we have assumed, 7.3 pounds, weighs about from six and one-fourth to six and one-half pounds, and as the heat is directly in proportion to the weight of the combustible, it is plain that a barrel of crude oil will not give as much heat as a barrel of reduced oil. The oil which is now used on the Grazi-Tsaritzin Railway, and which is believed to be safe to use, is an oil not below 300° fire test. It is fair to add that crude oil can be used on stationary boilers where it is kept in tanks and brought to the boiler in pipes.

The formulæ given above, and the tables, or rather the figures, which result from the comparison of the value of coal and oil in dollars and cents, go far toward explaining why petroleum has not as yet been used to a very much greater extent as a means of heat production, namely, in this country, and at the present time it is really more expensive to obtain the same amount of heat from oil than it is from coal. In the experiments already alluded to on the

Pennsylvania Railroad, it was actually found, with oil at thirty cents per barrel, that it cost nearly fifty per cent. more to take the same train of cars 100 miles by means of oil than by means of coal. Another very potent reason why oil has not and cannot, as we look at it, be used generally for fuel, is found in the following: The total coal consumption of the Pennsylvania Railroad, including all its ramifications, is about 8,000 tons per day. If, now, this fuel consumption was changed from coal to oil, the Pennsylvania Railroad alone would use over 26,000 barrels of oil per day, and this 26,000 barrels is over one-third, and at present nearly one-half, of the daily oil production of the United States, so that lack of supply in this country, at least, will, for a long time to come, prevent the use of oil in anything more than a very limited way. In Russia no difficulty of this kind occurs, and for two reasons. First, because the oil supply is enormously greater than it is here. While I was in Russia it was credibly stated that a new well had been struck which actually flowed more per day than the total daily production of the United States. The second reason is that the nature of the Russian petroleum is entirely different from American. With the largest portion of American petroleum, seventy-five per cent. is capable of being made into refined oil, leaving twenty-five per cent. of residues. In Russia the figures are exactly reversed; twenty-five per cent. only is made into refined oil, and seventy-five per cent. is residues, and these residues are what is burned. They have a fire test of about 320° to 340° , and look and, in truth, are very much like our ordinary reduced petroleum, known in market as "well oil," and used for lubrication.

The difficulty in regard to burning oil successfully has been overcome. Two other powerful difficulties still remain—increased cost for the same amount of heat, and limited supply, and it is for the future to determine whether either of these difficulties can be overcome.

As to the possibilities of the future it is difficult to say a great deal, but there certainly is very little hope for fuel oil as long as efforts are made to diminish production. It is possible, however, we think, that with present production, a limited amount of, say, 10,000 or 15,000 barrels per day of oil might be used to advantage as fuel, but it would probably require changes in the method of distillation with the idea in mind of making a fuel oil, and possible

changes in the methods of utilizing the heat generated, as has already been described, to get economy even in this limited way. There is also the rather paradoxical statement that those points farthest away from the oil fields can probably use oil to advantage, when it could not be used to advantage in the oil field itself. This is due to the fact that the same heat-producing power weighs less with oil than with coal, and consequently the freight, which is an important element always in the cost of fuel, would be in favor of the oil. In our judgment the future of fuel oil in this country, and until some other very much greater sources of supply are discovered, is in the hands of the refiners. By shaping the distillation in such a way as to produce a fuel oil at low figures, it can be burned, otherwise not.

SANITARY SCIENCE IN THE HOME.

BY MRS. R. H. RICHARDS, Instructor in the Massachusetts Institute of Technology, Boston.

[*A Lecture delivered before the FRANKLIN INSTITUTE, Friday, January 16, 1888.*]

The Lecturer was introduced by Dr. FRAZER, Professor of Chemistry in the INSTITUTE, and spoke as follows:

It has been said that "the sanitary engineer sprang into existence on the passing of the Public Health Act in England in 1848, from which date sanitary knowledge began to spread and develop itself until twenty years later it was recognized as a science and special branch of study."*

Since just twenty years more have passed, we may consider sanitary science as now emerging from childhood into maturity, and while it has the freshness and piquancy of youth with some of the vagaries of childhood, not yet sobered by the trials of life, still we may reasonably expect it to begin to bear fruit in deeds worthy of the child of the age of philanthropy, the age in which all are to be benefited by the knowledge of the wisest.

* Association of Municipal and Sanitary Surveyors. Address of President Gordon. Leicester, England, July 18, 1887.

America was not far behind England, for in 1850 Mr. Lemuel Shattuck presented to the Legislature of Massachusetts a report, from a sanitary commission, which was as intelligent and as sound in its conclusions as Edwin Chadwick's writings in England.*

In 1869, the first State Board of Health was organized, that of Massachusetts; to its early reports I shall have occasion to refer more than once. In 1876 there were twelve, and to-day there are thirty-three States which have a State Board of Health.

So far sanitary science has been an ambitious youth, dealing with large problems, such as the draining of vast marshes, the building of asylums and hospitals, the water supply and drainage of cities, all works on a large scale, and needing an expenditure of money which no other branch of science has demanded. But we must acknowledge that even the vast outlay has had its reward. For Sir Douglas Galton has recently shown, that the average number of lives saved in each of the five years from 1880 to 1885, by sanitary improvements, in England alone, was 102,240. "A record, noble almost beyond compare, to the credit of the engineer as the benefactor of his species."

And yet while we claim sanitary science as a new science, its motto to day is that expressive hygienic formula given more than 2,000 years ago by Hippocrates, "Pure air, pure water and a pure soil;" and all its efforts have been directed toward supplying the people with these necessities. But of what use is it to lay pipes carrying water to a community which still drinks at the well in the stable yard? or what use to build model tenement houses on clean soil, when in a year or two the occupants will have soaked it through and through with refuse which it is too much trouble to carry away? "Some years ago a wealthy and philanthropic land owner in one of our principal cities, conceived the idea of erecting a number of healthy houses, which should be built on scientific principles. Ventilation was especially sought, and the best talent at command was engaged to provide the necessary appliances; but when the houses were finished the owner found himself unable to retain his tenants except upon the condition that he would seal all his ventilators."†

* *Hygiene in America*. Bowditch, Boston, 1877.

† *House Drainage*. James C. Bayles, p. 15.

The public in general are becoming familiar with and tolerant of works of public benefaction. Legislatures vote money for the support of State Boards of Health without much grudging. Common Councilmen appropriate hundreds of thousands of dollars for a water supply, and sometimes for the consequent drainage; even small communities consider it advisable to tax themselves for the general health. One hundred and three towns, beside twenty-three cities, in Massachusetts alone, have a public water supply.

Most of these large works, which after completion remain under the charge of competent engineers, and are maintained year after year, have been very successful. Other works of public sanitation, the care of the sick and wounded in great hospitals, the control and suppression of contagious diseases, in short all sanitary measures which are under the immediate and entire care of skilled men, in positions not interfered with by politics or personal interest, are duly appreciated and sustained. But when the question concerns the houses the people live in, and the food they eat, the wheel of progress has neither rolled so smoothly nor so far.

To be sure in house construction great talk is made about the sanitary authorities consulted, although the builders go on in the old way. It rarely falls to the lot of the thorough sanitary engineer to have his plans carried out when it comes to dwellings. All such schemes as need the personal co-operation of the individual are very likely to miscarry.

Dr. Boardman in his paper, "Value of Health to the State," in the Sixth Report State Board of Health of Massachusetts, 1875, well expresses this. "Sanitary science comes into constant contact with personal convenience, avarice, mistaken economy, long-established customs and habits, and an erroneous judgment of the future by the favorable condition of the present and past."

To the owner, a house is a sort of outer garment, and it is as much of an insult to tell him that his house is not right as to tell him that his boots need blacking. To the dweller in flats or an apartment house, the house he lives in is no more a part of him than the car in which he rides to town, or the public hall in which he suffocates. He depends entirely on the owner, takes it all on faith, as he does his dinner at the restaurant.

The relative positions of public institutions and of homes has

WHOLE NO VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.)

entirely changed since the infancy of sanitary science. Then the condition of asylums, hospitals, and public institutions was in glaring contrast to that of the clean, airy and roomy houses of the well-to-do people of the middle class, and even to that of the dwellings of the poor peasant and tenant. To-day the hospital and public institution receives the best that sanitation can give. Whereas a century ago it was almost certain death to be taken to a public hospital with a broken leg or a dangerous disease, now I would rather take my chance in any large hospital than in nine-tenths of the well-to-do homes of our land, simply because the essential principles of health are not at all understood by the people at large, and alas! not by all our physicians, who as a rule have been educated to cure disease, not to prevent it. Too many of them have been taught to fight Nature's laws, not to stand by patiently as her adjutant.

This has been called the urban age, the age of cities, and it often seems as if most of the ills which sanitary science is called upon to cure arise from the close contact of human beings in the crowded life of the modern city. From statistics carefully collected by Dr. Farr, in England, the following estimates are made. A population of 16,600 souls scattered over 100 square miles of territory are liable to lose by death 282 of their number annually. The same number of people drawn closely together so that they occupy fourteen square miles may lose 415 annually. The same number crowded into the space of a quarter of a square mile are pretty sure to lose annually by death 647, or one-twenty-fifth of the whole number.

Another way of expressing the same idea is, that the nearer people live to each other the shorter their lives. From the same statistics it is seen that a distance of 147 yards between habitations gives to the occupants an expectation of living to the age of fifty-one years. When the distance is lessened to ninety-seven yards, forty years only may be counted upon. Double the number of habitations, so that the distance shall be forty-six yards, and the mean of life will be only thirty-five years. Crowd the houses still closer and leave only seven yards between them and the occupants cannot count on more than twenty years of life, or only half that which they may reasonably expect if the houses are 147 yards apart. Why, then, do people gravitate so surely, like the

moth to the candle, to the maelstrom which will certainly shorten their term of life?

It is this very crowding of many people into a small space which makes possible the necessities of to-day, the electric light, the supply of gas and steam for cooking and heating. The delights of music and art, are they not unattainable except in the midst of large populations whose numerical and financial support can alone sustain them? Scatter our population over the surrounding country and you would put back the civilization of the time at least fifty years. We rightly boast of the height to which we have reached, but we do not stop to count the cost, to note the number of those who have fallen by the way. Those who climb highest are the few survivors of the fittest.

If the question were put to us now and here, "Would you rather live to three-score and ten, but live half a mile from any neighbor, and twenty miles from any city, or would you rather take the chance of losing one-third of the time, and live in the midst of the dust and confusion which necessarily attends the passage of the rapidly-rolling wheels of modern progress?" Who of us would not say, "Let me live while I do live." In one of his recent stories, George W. Cable expresses this feeling in the words, "They had done that dreadful thing that everybody deprecates and everybody likes to do—left the country and came to live in the city." But, we hasten to ask, is there no remedy? Must the enjoyment of all that is rich and delightful be paid for with such a price? There is no doubt that a city of Hygeia* could be built in which the death rate, and especially the sick rate, could be lessened far below that in any country town at present known. This city would not have more than twenty-five persons lodged on an acre of ground. It would be clean and so carefully supervised that disease could not find a foothold. But, if such a city should rise in a night and be offered to us to-morrow, who would go to live in it? Who would bear all the restraint of such a clean place? Americans claim the right to be the victims of their own ignorance and carelessness. They will not brook bridges across tracks and gates on the cars. The true American wishes to take the risk he incurs in jumping on or off a moving train:

* *Hygeia*. B. W. Richardson.

and he also claims the privilege of living as he pleases. The picture of the city of Hygeia will be fascinating only when a large number of people are educated in the belief that health is the greatest of all blessings. The valuable little health primer, "Our Homes," written by Dr. Hartshorne, of Philadelphia, has before its title page these lines of Goldsmith :

"A time there was
When every rood of ground maintained its man :
For him, light labor spread her useful store—
Just gave what life required, but gave no more.
His best companions, innocence and health."

Most great undertakings, from the building of the Pyramids to the Panama Canal, have been carried out at an enormous expense of human life, and it seems as if the development of all modern inventions, and the possibility of modern luxuries were to be attained only by a like offering of one generation to the next, but it certainly behooves us to be sure that there be no unnecessary sacrifice.

To live safely in the city costs far more than to live safely in the country. Shall we save money or lives? At present we are economical of expenditures and lavish of lives, as the examination of the vital statistics show. It is expensive to keep well in the midst of danger. The state has here to step in and assert its claim on the value of every man, woman and child to it, and to demand that it shall not be defrauded.

It has been said "that civilization, when it lifts man out of the savage state, adds to health and life and to length of days. But when it gives to civilized man more privileges than he deserves or requires, then civilization itself lapses back into practical barbarism, and nature, maintaining her unswerving and wise course, pursues her way even with death on her wings."*

As is natural to youth, sanitary science boasts of what it has done, rather than delights in calling attention to what remains to be accomplished. It is evident that the principles of water supply, clean building ground and all public improvements are well grounded, so that we may suppose that they will continue to gain in popularity. All great enterprises undertaken by sanitary engi-

* *Health and Life.* Dr. Richardson.

neering in its broad sense are a part of state medicine with which we do not now concern ourselves, but pure air and good food come under the personal control of the housekeeper. We have nothing new or startling to proclaim. We aim only to bring home to the householder his responsibility. *It remains for sanitary science to educate the people one and all.* It has to apply the knowledge it has gathered to that unit of the community, the home, for upon the welfare of the homes depends the welfare of the Commonwealth. It is therefore evident that upon this potent factor in public life should be lavished whatever of knowledge and of science the century has to give. At the birth of sanitary science this fact was recognized. It cannot be better expressed than it was in 1868 by Dr. George Derby, one of the apostles of state or preventive medicine, the first Secretary of the first State Board of Health in this country.

"The prevention of disease may be considered, first as regards the individual, or family, or household; and second as regards the community at large. What power have we to ward off disease from our homes? There are certain dangers to which we are exposed which a prudent head of a family may constantly bear in mind

"One of these and by far the most important, is from insufficient ventilation. Every man, woman and child is entitled to their full ratio of fresh air, to that amount which will both dilute and quickly remove all which has been spoiled by respiration and combustion.

"Fresh air is the great natural disinfectant, antiseptic and purifier, and not to be compared for a moment with any of artificial contrivance. There is plenty of it in the world, yet, disguise the fact as we may, there is no getting over the unwelcome truth that to provide it in abundance in our climate is expensive, since during seven months in the year it must be artificially warmed.

"All reforms are practicable whenever public opinion recognizes their expediency, and gives the necessary authority for their execution.

"Public health has so wide a field that help is needed from all. From the chemist, the engineer, the naturalist and from the humblest citizen as well as the highest statesman."

How, then, shall the home be reached in the most effective manner? How shall the moral responsibility of each individual be

awakened so that he will see to his own household first and then be a help and not a hindrance in carrying out measures for public benefit? How shall the people be instructed in the best ways of *obtaining* and of *maintaining* the three prime necessities of good health, namely, pure air, pure water and a pure soil? It is evident that a healthy community can be made up only by an aggregation of healthy individuals, and that upon the health of the individual must rest the health of the Commonwealth, as upon his wealth depends its prosperity, and upon his vote its political status.

Only one nation ever had this personal hygienic instruction, and only one national code of laws entered into the details of personal daily life with its sanitary requirements. The nation was that of the Jews, and the laws were those given by Moses. The nation had its reward, as will any nation to-day, which will take up in earnest the work of personal and home or family hygiene.

In this land of personal liberty, minute laws relating to daily life are not tolerated, but the truths upon which sanitary science is founded must be deeply impressed upon the public mind before we can look for great and important results. This popular education can be accomplished only gradually and by the patient and intelligent teachings of unselfish specialists, through the medium of newspapers, books, pamphlets and tracts. In all the avenues by which the masses of the people are reached, and in the opinion of many by that great artery of influence, the common school.

"The state, upon the legitimate ground of public economy and self-preservation, takes care of the primary education of the people; it, therefore, determines what secular knowledge shall be taught in the common schools. It may, and properly should, add the simple and ascertained laws of health and public hygiene to reading, writing, grammar, geography, arithmetic and the history of the country. It is a disgrace to our higher institutions of learning that they are still neglecting sanitary science."*

Dr. Wight also quotes Lord Derby as follows: "No sanitary improvement worth the name will be effective, unless you can create an intelligent interest in the matter among the people at large. You cannot make a population cleanly or healthy against their will or without their intelligent co-operation. This is why,

* *Maxims of Public Health*, p. 156. Dr. Wight.

of the two, sanitary instruction is even more important than sanitary legislation." Dr. Wight also makes a statement which, I believe, to be under rather than over the truth: "The unsanitary conditions of school buildings slacken the speed of educational progress more than one-third."

Grant, as we must, that some kind of instruction shall be given, in what must it consist? First, in what Edwin Chadwick called the sanitary idea; that is to say, "the idea that man could, by getting at first principles, and by arriving at causes which affect health, mould life altogether into its natural cast, and beat what has been hitherto accepted as fate, by getting behind fate herself and suppressing the forces which led up to it at their prime source." *

A sense of personal responsibility for the lives we have and the health we might have must be cultivated. We were not meant to drag out a miserable existence. We have not yet awakened to the fact that at least two-thirds of the illnesses under which we suffer are preventable, and that we are more and more to blame each day for allowing ourselves to lie under the unnecessary infliction. We are still in the middle ages in many things and in none more than in regarding disease as a special visitation of Providence, as something entirely beyond our control. Indifference to bodily health is a legacy handed down from the mediæval cloister. The ancients seem to have known better.

"Theoretically, we respect the physical foundations, but practically we say: 'We will build first our structure of domestic duties and social pleasures, of intellectual achievement, of philanthropic and church work, and then, if we find the physical underpinning a little shaky, we will prop it up with a tonic or a vacation.' But the physical life is no more to be established on this confused and chaotic system than the intellectual or the moral life. Health can be secured only by effort as continuous, as carefully adapted and as systematic as the processes of physical life themselves.

"If, for instance, we could save all our breathing for the year and condense it into the brief period after the spring cleaning, spasmodic effort would do very well. But, until the human body

* *The Health of Nations.* Dr. Richardson.

can content itself with an annual breathing spell, the daily, hourly, momentarily need of pure, fresh air should be respected." *

When the sanitarian attempts to press home individual responsibility, his hearers answer: "Is life worth living if we have to take such care of ourselves?" They cannot realize that if the habit was once formed, it would not be care, only second nature.

In blaming people for this indifference, we forget that a body of men obeys the same law as a body of matter, *i. e.*, a body in motion will continue in motion, and a body at rest will remain at rest, unless acted upon by some external force. It sometimes seems as if the inertia of the human race was intensified inertia. This is expressed by intense conservatism on the one hand, when it is called upon to exert itself, or when the impetus or the exertion must come from within, and on the other hand its extreme readiness to adopt any new idea or fashion provided the impulse comes from without, and especially if some great saving of trouble or of exertion is promised. For instance, when coal was first used it was in the cities where the price of land drives the householder to store coal, as well as in a measure to live, down cellar. When the country dweller ordered his coal he had it also put down cellar, whence with much toil it must be brought up again for use, and nearly every house, to this day, no matter how abundant the land about it, has all the coal put down cellar. Again, the furnace is usually in the main cellar, whence the dust rises through all the rooms of the house whenever the furnace is shaken and the ash-pit emptied, instead of being enclosed so that the ashes and dust have no communication with the air ways of the house.

Some unusually indolent individual once upon a time hit upon the plan of introducing water into every room in his house. Immediately other people followed suit, with never a thought where the waste water went to, nor with what the pipes were connected. In many cases the pipes went nowhere beyond the house walls, and if they did connect with the city sewer the chances were that these same pipes ventilated the sewers into the houses. It is highly probable that this one fashion alone has caused more death and misery than war, and yet people demand it and architects supply the fatal demand.

* *Home Sanitation*, p. 73. Annie E. Allen.

A certain amount of conservatism may be pardoned since the most enthusiastic sanitarian must admit that there have been many sanitary cranks who have been a source of much discomfort to their friends, and who have brought discredit on the whole cause. In many cases it has happened that what was intended as a benefit has proved far otherwise. In many houses the sewer has been a source of fatal disease instead of a preventive. Indeed, in some directions, so far has the zeal of sanitary science outrun its discretion, that it is in danger of losing the ground it has gained. It has provided the mass of people with appliances for which they have no use, and it is a peculiarity of sanitary appliances that they are made for use, not ornament, although many a so-called sanitary plumber fits up a house on the reverse principle. The architect who does sometimes know what is right, builds a house which is very nice while it is new, and all the joints tight, all the pipes clean and free—large enough and not too crooked for what he imagines they should carry; but he does not consider that a few months' use will make a great difference; that joints will open and traps become unsealed; that a miscellaneous collection of match ends, coils of hair, dish cloths, and coffee grounds, to say nothing of a score or two pounds of grease, will stop up his pipes, and that the ventilators will remain closed because it is too much trouble to open them.

The criminal carelessness and neglect which so frequently rouses us to indignation against builders, really comes from the apathy of the public. A man does not buy a cotton mill, or a machine shop, without seeing for himself that everything is in order, that all the machinery works, and that there is power enough to run it successfully; but that same man will, in nine cases out of ten, buy or build a house for his family to occupy without seeing a single inch of pipe, without considering whether there is any outlet for the products of combustion of the numerous gas jets, without looking at the children's rooms to see if they can have fresh air without a draught. All is taken on blind faith, and that man will mourn the heavy dispensation of Providence when his child dies of diphtheria and his wife of typhoid fever.

It has been said that the highest modern civilization is shown, not so much by costly monuments and works of art, as by the perfection of house conveniences. But alas! security does not always

come with refinement, and the true conveniences of the house are those only which add to the health and comfort of its occupants.

We boast loudly of our modern houses, and proudly show their increasing luxury and artistic furnishings (we certainly have good reason for boasting), but how about the people who live in them? What is life bringing them? Are they merely lounging in the lap of luxury, becoming daily more averse to activity, more self-indulgent, caring mostly for themselves? What are the pictures most commonly given to us in the current literature of the day, of the home life of our people? The husband and father is engaged in eager struggle for wealth, that his family may take a high place in society, or he is engaged in many large schemes for public benefit, and has no time to go about his house and examine its condition. He hires many servants, who ought to know their business. He never thinks of looking at the furnace, even if he is the proprietor of a machine shop, and understands how to make every pound of coal do its utmost there.

The wife and mother has her social duties and her charities to look after. Her children's clothes must be just right, and they must have their music and their French at the hours appointed; if they are late to breakfast and eat a hurried dinner, no matter, "it is safe to let children alone, they will get enough to eat."

The parlor maid is duly instructed in her duties, and everything is quite right in the dining-room, but what an expression of amazement would come over many a housewife's face did you ask her what was the condition of her cellar, or if 300 cubic feet of air a minute passed through every room. The children hurry off to school, hurry home, snatch a bite and run off to music, or to some appointment with a school-fellow; all is in a froth and a tumult; no time is given to the homely duties of the house. I sometimes think there can be no home without loving hands busied in the preparation of the daily tasks. The home must have the individual flavor about it. The ready-made house and ready-made outfit, servants trained by someone else to conventional duties, all this is to blame for the lamented decay of home life. Individual and family responsibility must be more fully recognized in school and in society before we can have the perfectly healthful home.

The child poring over his book in the evening, with his head close to a student lamp, complains of a headache. "Those lessons,"

says the mother, not stopping to think that it is the close air and the heat from the lamp, no matter how many laws of chemistry she has studied. She might remember that hot air being lighter rises to the ceiling and strives to get out at the top of the room; only an open fire or mechanical ventilation will pull it down and take it out of the bottom of a room. There is no connection between knowledge and daily life in the minds of most people.

One thing most urgently needed is co-operation of all those concerned both in building and living in houses. The architect must first of all understand his limitations. He must remember that the ancient civilization, whence he has his ideas of architecture, was developed in a warm climate, where the charcoal brazier, or the fire of a few sticks against the wall, gave all the heat needed. Civilization has gone so far toward the North Pole, that the open windows of the Greeks and Romans can no longer serve as fresh-air passages all the year round. One authority has said, "it is a fact which, unfortunately, does not admit of intelligent contradiction, that in the architectural practice of the time, very little attention is paid to the laws of health." The same author gives the *reason* on another page: "The architect in general practice cannot insist upon a due observance of hygienic laws in house construction, and compete successfully with those in the profession who are less conscientious in such matters. If his clients neither know nor care whether a house is well or badly drained, why should he drive away business by demanding that we shall pay for good plumbing work?"

Here again the public follows blindly the example of past ages, and shows its inertia in blaming the new fashions for its troubles. One writer has said, "there is probably more gratuitous abuse of one kind and another lavished upon plumbers than upon all other mechanics, directly or indirectly connected with the building trades. When the plumber, whom we call in to mend the pipe in some inaccessible place, has to tear up our floor or break down our walls, we never think of blaming the architect or builder."

To be a healthy home, the modern house, in a modern city, needs to have all the physics and chemistry of air and fire and water, as well as the mechanical points of construction, fully understood and carried out, both by the builder and the occupants. All must be of one accord, and the owner must expect to pay for the

good work without grumbling. We must frankly acknowledge that it costs money to be healthy and yet to enjoy the conveniences of modern life.

I must now speak some plain words to the housekeepers of my audience. I hope they will forgive me. I know no man will dare say it in so many words, and, therefore, it is the more incumbent upon me to do so. I am sure if the much-abused architects and builders were to speak their minds, they would say that it was the women who hindered them from carrying out the plans which they know to be best. How can a builder survive the scorn which greets him when he proposes to leave all the drain pipes exposed? How can he put hoods over the gas burners when the artistic sense of the woman who is to occupy the room is offended? How can he convince the women of the family that they should wear thicker clothing in the house in the winter and not expect to have a whole house made so comfortable that they can wear thin slippers and silk dresses in weather approaching that of the Arctic regions? Does it avail for him to argue with them? Must he not cater to their tastes? And as they are the ones who live nine-tenths of the time in the house, the man of the family lets them have their own way. There is a wide field for the sanitarian in girls' schools; the chemistry and physics which are now taught in them should have practical application to daily living, and not be given as disconnected subjects with no bearing whatever upon the home life. Women have been very averse to hearing such unpleasant topics spoken of, and all subjects relating to health have been tabooed. There is a change noticeable, however, and women themselves are awakening to the opportunities opening out before them. Mrs. Plunkett, in her "Women, Plumbers and Doctors," led the attack. College graduates form sanitary science clubs. The Boston Society to Encourage Studies at Home offers a course in sanitary science. A woman, writing for women, has said: "In this age of scientific enlightenment and invention and wide-spread information, ignorance of the primary conditions of health and vigor is unpardonable. A knowledge of sanitary principles should be regarded as an essential part of every woman's education, and obedience to sanitary laws should be ranked, as it was in the Mosaic code, as a religious duty." *

* *Home Sanitation*, p. 73, Annie E. Allen.

As this is supposed to be an age of money worship, one of the outside forces to be brought to bear is that of benefit to the purse. The individual must be convinced, as most states have already been convinced, that health is true economy. It has been estimated that on a broad average each individual loses from fourteen to twenty days a year by sickness. In a family of six persons, this would be one-third of a year, with probably as much outlay for physician, nurses, medicine, delicacies, extra fuel and travel in search of health, as all the other expenses of the family. In the case of the workingman this often means debt and despair. If it does cost much to give every member of the family his inherent right, pure air to breathe, it is economy in the end.

There is one point upon which I cannot forbear to touch. It is a subject which requires the most delicate handling, as it is impossible to treat it without disturbing some one. No subject has had so many theories concerning it, all of which have failed when put in practice. On no topic are people so sensitive. Even the best sanitarians have touched it lightly. Physicians avoid it. No one knows just how to approach it.

If I wished to make you smile, I could not do so more surely than by announcing to you that I was now about to consider the question of hygienic food. Yet I must in all soberness, ask your indulgence while I discuss the bearing of food upon health, promising that I shall consider it only from the hygienic standpoint, and that if anything sounds impracticable from a social standpoint, that I leave to be reconciled by those who have to balance their accounts between *society* and *health*.

The sanitarian says that an exaggerated importance is attached to both eating and drinking, and in the next breath he says that not half enough attention is paid to the providing of proper food. These apparently contradictory statements can be reconciled only by tracing certain customs back to their sources, and noting the causes which have produced certain effects in our daily life.

Eating and drinking was the principal *enjoyment*, as well as *employment* of the mediæval age. It was a step forward, indeed, to be able to *enjoy*, since the earliest races were probably able only to obtain a bare subsistence.

Baronial castles resounded with the revels of feasting, and since the feasters were likely to be killed in the morrow's foray, it was,

perhaps, as well, since intellectual advancement was not possible in such war-like times.

The life of the cloister was a protest against brute feasting, and we owe much stored learning to the ascetics who went to the other extreme, and only ate under protest, because it was necessary to keep body and soul together.

We seem to have combined the evils of both the castle and the cloister. We disregard every law of dietetics; we pay no attention to the real needs of the power-producing machines which we call our bodies. We give no heed to the high and noble possibilities, which only a perfect physique can ensure. Our tables are loaded with mixed and incongruous materials, far less digestible than the baron's roast ox. At dinner parties we eat, night after night, what is set before us, and give never a thought to the years each dinner is taking from our lives. Witness the slaughter of our public men! Can we not have the æsthetic side without sacrificing the hygienic? That we have become so careless is partly through ignorance and partly through thoughtlessness. It has been very unfashionable to consider the physiological side of the food question, and if one takes it up on the economical side, he is considered a traitor to American principles.

The advance in physiological chemistry has in the past few years shown us that non-hygienic diet has to answer for at least one-half the illnesses of civilized man. What priceless hours do we needlessly waste because of a little thoughtless indulgence, or even simply because it is the fashion to eat certain things. This is a state of things unworthy an intelligent people.

"We have not the least idea of the mischief that indigestion does us from the beginning of our lives. We say a person only suffers from indigestion, but if you cannot digest your food what do you expect to do?"*

It is stated, on good authority, that insane asylums are filled with the victims of indigestion and not with the victims of brain work.

Ask any physician what is the greatest drawback which he meets with in having his instructions carried out in the homes of his patients, and he will tell you that it is in the preparation of food.

* *Health.* W. H. Corfield.

When a typhoid fever patient has a relapse, probably, in nine cases out of ten, it is because some loving and devoted member of his family or some careless nurse, has neglected a very small precaution. It is a terrible thought, and yet we must face some terrible truths in order to remedy the trouble.

To my mind there is but one efficient remedy for this gross ignorance and misapprehension of the office of food, and that is to have the science of food (not the technique of cooking) taught in all our public schools. The advocates of temperance would accomplish far more for their cause if they would advocate this fundamental teaching rather than teaching a special topic upon which we are rather more ignorant than upon any other physiological question.

Make the simple, fundamental, well-known principles of diet a part of the natural science training in the school, add interest and point to the teaching by classes in cooking, not for the sale of the dishes prepared, although they should be well done, but for the sake of the illustrations they give of the principles taught. The brains of most of us are reached quickest through the fingers. The element of time taken enters into the permanence of the brain impression.

While we know enough to make a beginning in this line, there is great need for further investigation. We very much need another Count Rumford to awaken an interest in the scientific side of food for the people. Matthieu Williams, an eminent metallurgist in England, and Prof. Atwater, the chemist, and Edward Atkinson, the political economist in this country, are calling attention to these problems, but they must be supported by public opinion.

"This work of the purveyor and the cook—the selection and preparation of our food—requires more intelligence of its purposes and means of accomplishing them, more consideration, careful judgment and discipline than any process submitted to human supervision. Much disease and disability, much distress and great loss of working power, both in body and in mind, and even premature death, are brought upon us in consequence of the misadaptations by the provider and unfitting preparations of the cook. These, the provider and the cook, are our life makers. We are in their hands, to make us what they can or will—strong or weak, buoyant or depressed, active or sleepy, clear, bright, quick-

witted, or dull and torpid. No office has such control over human power and effectiveness as that of the housekeeper and the cook. An office that yields so much power can be filled only by persons of high intelligence, appropriate culture and thorough discipline. No office offers so wide and rich a field for the exercise of talent and scientific acquirement.

"The eater's ideal of good food generally corresponds with the caterer's. There is also a very common sort of heroism or physiological stoicism in regard to eating. People often say, with self-complacency, that they can always eat what is set before them. Our domestic animals are more favored than their owners in respect to nutrition.

"The price, in money, in the general market, or the financial value of any service, is a good indication of the world's estimate of its importance. The wages of a cook are much lower than those of the maker of our garments. The groom who feeds the horses is paid twice as much as the one who feeds the family. According to the natural law, the character of the supply rises and falls in accordance with the estimate that is put upon it and the reward which is paid for it, in this as in other occupations. The talent which can rise high avoids the food laboratory, where it is meagrely paid, and goes to the clothes laboratory, where it is paid generously." *

Though this was written fourteen years ago, is not the same thing true to-day, and is it not a reproach to the mass of educated women that it is so? I have said elsewhere, "The time has come when the same kind of care must be given to the food of the family as the stock-raiser gives to his animals. The modern stock farm has given us most of the scientific knowledge we possess on the question of foods, and this is so because it pays to know the composition of their food. Shall the human animal be considered of less consequence?" †

It would seem appropriate to celebrate the coming of age of our youngest science in some manner which shall prove of great advantage to all mankind.

* *Fifth Annual Report of the State Board of Health of Massachusetts*, 1874. p. 376. Dr. Edward Jarvis.

† *Food Materials and their Adulteration*.

It is a pertinent question to ask, what is most required in the way of sanitary effort? We have fairly good sanitary laws; we have Boards of Health and inspectors; we have the sanitary engineer proper, who attends to the construction of water works and to the draining of marshes; we have the inventor of safety appliances—alas! we have a surfeit of him; we have builders who can construct houses very perfect while they are unused. What more do we need? We need missionaries to go about among the people and show them the dense darkness in which they are living. There is knowledge enough available but “little of either fame or profit can be expected to result from this preliminary work in the field of sanitary reform.”*

Hence there is required the true missionary enthusiasm, the philanthropic spirit, and most of all a faith in the responsiveness of men and women when they are once shown “how to do it.”

We need those who are capable of showing people how to make the best of the homes they have, and of awakening a desire for better conditions. For this work there is needed a new profession, a home sanitarian, a home adviser, one who knows how to examine a house, not while it is empty, but while it is throbbing with the family life, one who can go the daily rounds with the house mother, and suggest many little points which make or mar the healthfulness of the home.

This is an office which the busy physician can never perform and which, until the physician's training is different, he is not, as a rule, competent to perform. The sanitary engineer, as at present trained, does not fully meet the requirements. Why should there not be the trained doctor of the home, as well as doctors of medicine? There are training schools for nurses; why should there not be training schools for home sanitarians, or better yet, since, beside a general knowledge of the laws of health, there is needed for this work a practical knowledge of the laws of chemistry and physics, so far as they relate to combustion, and to the movements of air and water, and especially a knowledge of the chemistry of food and nutrition, why should there not be a course in sanitation in the technical schools and the colleges? I believe that the University of Edinburgh does confer the degree of bachelor of

* *House Drainage*. Bayles.

science in the department of Public Health, and why should there not be a department of Home Health in American universities?

In this plan the family physician must co-operate, and since preventive medicine is slowly but surely making its way, in the not very distant future the two offices will be united and every family will have its physician paid by the year to keep its members in good health in so far as they will take proper care of themselves. From the eagerness with which mothers seize on anything which they feel will help them in their homes, I am led to believe that if some of the college-bred women would take up the profession of home sanitation or of sanitary adviser to the community in which they live, the result would be of the greatest benefit to the country.

That this is not beyond a woman's powers has been abundantly proven, and while this new profession ought not to be limited to women, yet in many of the points indicated improvements can only come through the better education of the housekeeper, and this requires teachers who are familiar with the difficulties with which the housekeeper has to contend.

Let the scores of young women who are looking to medicine as a wide field of usefulness go a step farther and add to their medical course a thorough training in preventive medicine and home sanitation. When this is done we shall soon see a reform in daily living worthy to usher in the twentieth century.

STANDARD MEASURES.

BY E. A. GIESELER, C.E.

[*A Lecture delivered before the FRANKLIN INSTITUTE, February 17, 1888.*]

Mr. GIESELER was introduced by the Secretary, and spoke as follows :

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN :

To measure the length of a line means to determine how many times the unit of length is contained in it. If the measurement is made by actual comparison of the unit with the unknown quantity, then it is called a *direct* measurement; if it is made by computation or construction, then it is called an *indirect* measurement.

On account of the imperfection of our instruments, as well as our sensual organs, direct measurements cannot be made absolutely correct, but will in all cases only be more or less close approximations to truth, the closeness of approach depending on the quality of instruments employed and the degree of care and ability with which they were handled. For these reasons, the direct measurement of a straight line, which is easy and simple in theory, presents great practical difficulties when high degrees of exactitude are demanded. The primary requirement will always be the knowledge with the greatest possible exactness of the unit of length, a requirement the importance of which has been fully recognized only in modern times.

The original units of length were found in the arm, the palm, the thumb, the foot, the step, etc., and from these various dimensions of the human body many of the still existing units have been derived.

The actual employment of dimensions of the human body for the purpose of determining the unit of length is not, as one might be inclined to think, a matter of a very remote past, in proof of which I will quote a book on surveying, published in Germany, by Jakob Koebel, about 340 years ago. In this book, the author

gives the following instruction (accompanied by a wood cut, which is reproduced here), as to how the length of a foot is to be found :



“To find the length of a rood in the right and lawful way, and according to scientific usage, you shall do as follows: Stand at the door of a church on a Sunday and bid sixteen men to stop, tall ones and small ones, as they happen to pass out when the service is finished; then make them put their left feet one behind the other, and the length thus obtained shall be a right and lawful rood to measure and survey the land with, and the sixteenth part of it shall be a right and lawful foot.”

With such and similar crude methods to determine the unit of length, there could be no general concord in regard to it. Its length would be found different each time it was determined and a bewildering variety was the necessary result, which in many countries extends into quite recent days. In Italy, for instance, there existed in the year 1832, 215 foot measures of different length, and in Germany, at the beginning of this century, there were certainly not any less, probably many more. Some of these, with their lengths expressed in Parisian lines (144 lines to the

Parisian foot), are given in the following table, from which it will be seen that the differences between their lengths in some cases are very considerable:

Table, rendering the length in Parisian lines, of some of the foot measures in use in Germany about 1790.

	<i>Parisian Lines.</i>
1. Thorn, ...	117'8
2. Cologne, ...	121'0
3. Weimar, ...	125'0
4. Saxony, ...	125'5
5. Brunswick, ...	126'0
6. Frankfort, ...	126'2
7. Stuttgart, ...	126'8
8. Hamburg, ...	127'0
9. Danzig, ...	127'2
10. Dresden, ...	127'5
11. Munich, ...	128'0
12. Strassburg, ...	128'2
13. Bremen, ...	128'3
14. Lippe Schaumburg, ...	128'6
15. Mecklenburg Schwerin, ...	129'0
16. Bavaria, ...	129'4
17. Ulm, ...	129'5
18. Oldenburg, ...	131'2
19. Augsburg, ...	131'3
20. Halle, ...	132'0
21. Nurnberg, ...	134'7
22. Leipzig, ...	135'2
23. Prussia, ...	139'1
24. Vienna, ...	140'0

That such a chaos in regard to length measures could have been endured seems almost incredible now, but it must not be forgotten that in former times, when countries were less densely populated, and communication was difficult and slow, the importance of uniformity in this respect was not so universally felt as it is to-day. These remarks in a measure also apply to the United States, where during the Colonial and a great part of the Administrative period many units of length existed, which were considerably at variance amongst each other. While from the very beginning of our history the old English foot was introduced into the Colonies, and while we have therefore escaped the greater deviations that would necessarily have been incident on the independent creation of units of length in different parts of our coun-

try, we have not escaped the smaller deviations incident on inexactitude in copying the unit of length.

Hence, in a great measure, the perplexing difficulties and contradictions that are frequently encountered, when old surveys have to be referred to. In the surveys, for instance, made at various times of the land now covered by the city of Brooklyn, four different foot lengths have been employed, which are designated by Brooklyn surveyors as follows :

- (1) The United States Standard ;
- (2) The Bushwick Standard ;
- (3) The Standard of the Twenty-sixth Ward ;
- (4) The Williamsburg Standard ;

the difference between the longest and the shortest of them being about two inches in 100 feet.

The city surveyor of Brooklyn, when laying out a lot, has therefore to measure with the standard employed in the survey of that particular vicinity, so as not to set himself at variance with the old maps and surveys. In one case, the non-observance of this rule has led to the following unique state of affairs : In a block which is twenty inches too long, according to correct measurement, the lots have been laid out by starting from the two corners and measuring towards the middle with correct measurement. The result was that a strip of land twenty inches wide, belonging to nobody, remained between two of the centre lots. Houses have since been built on these lots, and between them still remains the ownerless strip of land, for which the city of Brooklyn cannot collect taxes from anyone, and which is therefore, from time to time, put up for sale on account of unpaid taxes.

The first attempts to regulate the question of length measures were made in France. In the year 1668, an iron toise (six feet) was inserted into one of the stone steps of the " Chatelet " in Paris, and this so-called " Chatelet Toise " was accepted thenceforward as the standard measure of France.

About fifty years later, Newton became convinced, through his philosophical researches, that the form of the earth could not be a true sphere, but must be an oblate spheroid on account of the stronger centrifugal force at the Equator. If this was true, then a degree of meridian measured near the Equator could not be as long as one measured near the Poles, a deduction which was not cor-

roborated by the actual geodetical measurements in existence at that time. In order to decide the dispute that arose in the scientific world on this question, the French government resolved to have measured two meridional arcs, one as near to the North Pole as possible, and the other in the vicinity of the Equator.

Two expeditions were accordingly sent out, one, under Maupertuis, to Lapland, and one, under Bouguer and de la Condamine, to Peru, each of them being furnished with an exact copy of the iron toise let into the stone step of the Chatelet. The Lapland expedition was shipwrecked on its return voyage, and on this occasion its iron toise was damaged to such an extent as to make it unfit for further use. The Peru expedition, however, returned with its iron measure in good condition, and the length of this so-called "Peru toise," at a temperature of 61° F., was now made the legal standard of France. The motive for this action on the part of the French authorities consisted in the fact that the proportion of the "Peru toise" to certain geodetical dimensions was known, and thus the idea of the natural standard was already foreshadowed. It was clearly defined by the two leaders of the Peruvian expedition as a measure, based on some constant length to be found in nature, and related to the same in a simple proportion, which would easily and permanently impress itself on memory, so that if the measure itself, and even all written records referring to it were to be lost through some catastrophe, it might always be reconstructed by re-measurement of the natural constant on which it was based. Bouguer recommended to adopt for this purpose the length of the second pendulum on the forty-fifth latitude; Condamine its length on the Equator.

Neither of these recommendations was carried out, and in the course of time they dropped out of sight entirely, until about fifty years later, under the reign of Louis XVI, when they were revived, together with a third proposition, namely, that of adopting the forty millionth part of the circumference of the earth, as the standard unit of length. After mature consideration on the part of the most eminent French scientists, this latter proposition was finally adopted, the main objection against the two first ones being that their adoption would carry the foreign element of *time* into the definition of the unit of *length*. In contradiction of the very common error that the metric system was given to the world by the

French Revolution, it may be stated here, that the decision in regard to its creation and introduction was reached under the reign of Louis XVI, before the outbreak of the Revolution.

In order, now, to obtain the length of the natural standard decided upon, as accurately as possible, the French government ordered a measurement to be made of the meridian of Paris between Dunkerque and Barcelona. This work was executed by Mechain and Delambre between the years 1792 and 1798, and from the results of it the meridional circumference of the earth was deduced, and the forty millionth part of it was made the French unit of length under the name of "metre."

Measurements executed subsequently by Lambton, Mudge, Svanberg, Schmidt, Gauss, Bessel and others, and made by the aid of finer instruments than were at the disposal of the French scientists, have shown the earth's quadrant to be about 860 metres longer than found by them. In the strictest meaning of the word, the metre cannot, therefore, be looked upon as a natural standard.

The length found by Mechain and Delambre was deposited by them in the State archives at Paris in the shape of a platinum bar about one inch wide and one-quarter inch thick, the two ends of which were one metre apart at the temperature of melting ice.

The careful construction and safe-keeping of such actual standards is looked upon to-day as the real and only safeguard against the loss of the unit of length, while the idea of the natural standard is not any more entertained.

The modern standard measures are kept in places affording the greatest possible safety, and are never used for actual measurements, but only for comparing purposes, this even being done under strict regulations. The Imperial Standard No. 1, of Great Britain, for instance, is accessible only once in twenty years, while for the ordinary purposes of comparison a copy of it, No. 6, is kept at the British Standards office, which is accessible at all times. The comparing of other measures with the Standards is done by means of instruments devised for this purpose, and called comparators, which will be described further on. There are two kinds of standard measures in use, viz : end measures and line measures. In the first-named the length of the unit is defined by the distance at a certain temperature between their ends ; in the last-named it is defined by

the distance at a certain temperature between two lines drawn on their surface at right angles to the direction of their length.

When comparisons are made, the measures are generally supported on rollers, and it is unavoidable that the weight of the bar causes a slight flexure between the points of support. The comparison is, therefore, not made as it should be, with the actual length of the bar, but it is made with the cord of the curve into which it has been bent. In the case of end measures the measurement is taken from the centre of one end to the centre of the other end; that is, the cord pertaining to the neutral axis of the bar is measured. In the case of line measures, the measurement is taken on the upper surface; that is, the cord pertaining to the upper fibres is measured. Now, it was supposed that the length of the neutral axis cord was the one most approaching the true length of the bar, and for this reason end measures were formerly considered preferable to line measures.

Aside from this, end measures possess an advantage in the greater facility with which comparisons can be made by means of them, an advantage which is, however, offset by the danger to which their ends are exposed of becoming damaged through the contact into which they are generally brought with peculiarly constructed levers during comparison. It is said that the ends of the platinum Standard metre of the Paris archives were damaged after a comparatively short time to such an extent as to impair the correctness of the measure. To prevent further damage, actual contact during comparison with this Standard has since been forbidden by law.

The only way to overcome this defect of end measures is by constructing their ends of a very hard material, that will not appreciably suffer under the contact with the levers of the comparator. As a noteworthy example of this kind, I will here mention the old Prussian Standard, made in 1837, by Bessel, and probably the finest end measure that ever was constructed. This Standard consists of a cast-steel bar of square cross-section, into each end of which is inserted a sapphire, ground in the shape of a frustum of a cone, and set in gold in such a way that the smaller end of the stone protrudes a trifle beyond the end of the bar, and that the two sapphire ends are three feet apart, at a temperature of $16\frac{1}{2}^{\circ}$ C. Injury to the ends of this Standard is prevented by their extreme

hardness, and a displacement of them through the rusting of the bar is prevented by the gold setting of the stones.

The difficulties incident on the construction of such a standard have led in our days to the very general adoption of line measures, to the discussion of which I now proceed, taking as examples some of the Standards that are kept in the Coast Survey Office at Washington.

The first Standard measure of the United State is a bronze scale six feet and ten inches long and subdivided on silver to tenths of inches, which has been prepared for the Coast Survey of the United States by Troughton, of London. When this scale arrived in America it was subjected to a very close examination by Mr. Hassler, then Superintendent of the Coast Survey, and as a result of such examination the yard comprised between the twenty-seventh and the sixty-third inch was designated as the one most conforming to the average of the whole scale. On the strength of this, such yard was adopted by the United States Treasury Department as a Standard at a temperature of 62° F.

In the year 1856, the British government presented to the United States two authentic copies of the British Standard of length, which are designated in Washington as :

Bronze Standard No. 11 and Malleable Iron Standard No. 57.

Both are bars of square cross-section and somewhat longer than a yard ; in the vicinity of each end there is a circular hole sunk down to the centre of the bar, into the bottom of which a small gold disc is inserted, on which are engraved five fine lines, viz : two in the direction of the length of the bar and three at right angles to them. The length of one yard is defined by the distance from the centre transversal line in one hole to the centre transversal line in the other hole, the parts of those lines to be used which are situated between the two longitudinal lines. The standard temperature was given by Mr. Airy, the Royal Astronomer, for the bronze bar at $61^{\circ} \cdot 79$ F., and for the iron bar at $62^{\circ} \cdot 58$ F. The object of locating the graduation of these Standards in the neutral axis of the bars, was to eliminate the error resulting from flexure, which was discussed above.

In comparing the two authentic Standards with the Troughton scale, it was found that the latter was too long. The intention having been to adopt the English measure and the Troughton

scale having been procured only with a view of getting as exact a copy as possible of it, it was now decided to introduce the authentic Standards received from the British government in its stead. This subject will be discussed more fully further on.

When measures constructed of different metals are compared with each other, then careful measurements must be made of their temperature, so as to take into proper consideration their different expansion. But while these measurements may correctly give the temperature of the surrounding atmosphere, they may, under circumstances, not give the exact temperature of the bars themselves. In order to obtain this value, which is evidently the one required in a direct and more exact way, Standards have been constructed, which form metal thermometers, on Borda's principle, and as an illustration of these, I will now describe the Standard metre, which was presented to the United States by the French government about 1850.

This measure is a planed and polished steel bar, the two ends of which are one metre apart at the temperature of melting ice.

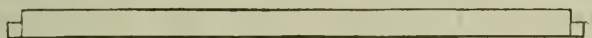


FIG. 1.

Upon each end of the bar there is screwed a small steel prism, reaching about half way across it, as shown in *Fig. 1*; the joints between the prisms and the ends serve as lines and the measure is therefore an end measure as well as a line measure. This steel bar rests upon a thicker and somewhat longer bronze bar, the two ends of which project beyond it, as shown in *Fig. 2*.

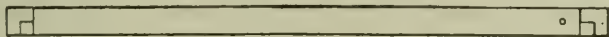


FIG. 2.

At one end the two bars are united by a pin, while at the other end they are free in their motions of expansion; to prevent any sideway deviations during these, there are four guide pieces attached to the underlying bronze bar, the top surfaces of which extend up flush with the surface of the steel bar.

One of the guide pieces at the free end of the bars bears a graduation and opposite to it the steel bar bears a vernier, by

means of which the relative movements of expansion of the two bars can be read off to hundredths of a millimetre.

This system of bars was placed in melting ice and kept there for two hours; the vernier at the free end then read 4.42^{mm} .

Then the system was placed in boiling water for two hours, when the vernier at the free end was found to read 3.80^{mm} .



FIG. 3.

The difference of expansion between the two bars corresponding to a difference of temperature of 100° C. was, therefore, found to be $4.42 - 3.80 = 0.62^{\text{mm}}$, for a length of 954^{mm} , that being the distance from the fixed point near one extremity to the zero of the vernier near the other extremity.

In order to determine the absolute expansion of each bar, an instrument was constructed by means of which a constant length could be inscribed on them. This instrument consisted of a steel beam compass, the two points of which were one metre apart at the temperature of melting ice, and which was constantly kept in a trough of melting ice, through the bottom of which its points protruded. The bars were now placed in melting ice for two hours and then the beam compass, always remaining in its trough, was placed on one of them in such a way that it rested lightly on one of its points, while with the other one a short arc of a circle was described; then this latter point was allowed to rest at the extremity of the arc just drawn and a similar one was described with the other point. Both the steel and the bronze bar, having been marked in this way they were now immersed in boiling water for two hours, and at the end of this time the process of marking on them the constant length of the beam compass was repeated in precisely the same way as before. The bars having lengthened under the influence of the higher temperature imparted to them, the distance between the second two marks would, of course, fall short of the distance between the first ones, and the difference between these two lengths rendered the absolute expansion for each bar for a change of temperature from freezing point to 100° C.

The following results were in this way arrived at :

Expansion of bronze bar, corresponding to 100° C., 1.7030^{mm} .

Expansion of steel bar, corresponding to 100° C., 1.0502^{mm} .

The difference between the two absolute expansions is 0.6528^{mm} , which renders 0.6228^{mm} for a length of 954^{mm} , a result which agrees very well with the one found before by reading the vernier.

The coefficients of expansion corresponding to a change in temperature of 1° C. are :

For the bronze bar, $B = 0.017030^{\text{mm}}$.

For the steel bar, $S = 0.010502^{\text{mm}}$.

The difference between the two, 0.006528^{mm} , reduced to a length of 954^{mm} , is 0.006228 , which is the amount of change in the reading of the vernier for a change of temperature of 1° .

At the hand of these figures, it is now easy to determine the actual length of the steel metre for any given reading of the vernier. Let t be the temperature at which such reading is taken and let the following designations be introduced :

$M^0 = 1^{\text{m}}$ = length of steel metre at 0° C.

M^t = length of steel metre at t° C.

$l^0 = 4.42$ = reading of vernier at 0° C.

l^t = reading of vernier at t° C.

Then we have :

$$l^t = l^0 - 0.006228 t$$

or

$$t = \frac{l^0 - l^t}{0.006228}$$

Introducing into this equation the value for t , which we obtain from $M^t - M^0 = S t$, wherein $S = 0.010502^{\text{mm}}$, we have :

$$M^t - M^0 = \frac{l^0 - l^t}{0.006228} S$$

or

$$M^t = 1^{\text{m}} + (4.42 - l^t) \frac{0.010502}{0.006228}$$

in which equation the second term on the right side gives the amount in millimetres to be added to one metre in order to obtain the actual length of the steel bar at a temperature of t° C. The

amount of this temperature can be determined from the second equation given above.

Before leaving the subject of standard measures proper, their latest form should be mentioned, as devised by the International Commission on Weights and Measures, at Paris. This commission was created about 1870, and consists of delegates of nearly all civilized countries. Under its supervision standard measures of length are made of a composition of platinum and iridium and furnished to applicants.



FIG. 4.

The shape of the cross-section of these standards, which is shown in the diagram, has been devised with a view of combining lightness and strength, so as to reduce to a minimum the error incident on flexure. In the line measures, the graduation is located on the plane indicated by a heavy line, and in the end measures the point of contact is in the centre of the cross-section. As a matter of general interest, it may be added that the price of one of these standards is \$2,500.

Having in the foregoing discussed various forms of standard measures, we now proceed to inquire into the appliances by means of which other measures are compared with them. Obviously there must be two classes of these comparators, one for end measures and one for line measures. The foundation principle of all of them, however, whether they belong to the first or to the second class, is the same, viz.: that of magnifying the exceedingly small quantities with which they deal, in a known proportion, to such an extent that they can be discerned and measured.

One form of the first class is based on an application of levers with short and long arms, as shown in diagram 5. The fulcrum of the lever *A* is connected immovably with the support on which the bar rests, while that of the lever *B* can be shifted by means of a micrometer screw with a graduated head. The long arm of each lever carries a vernier at its summit, moving alongside of a graduated arc and is pressed in the direction of the arrow by means of a light spring. When a comparison is to be made, then

first the standard measure is placed between the short-curved arms in such a position that the vernier of lever *A* is moved through the contact to the zero mark of its arc; then the fulcrum of lever *B* is shifted by means of the micrometer screw until its vernier also reads zero, and now the reading of the head of the micrometer

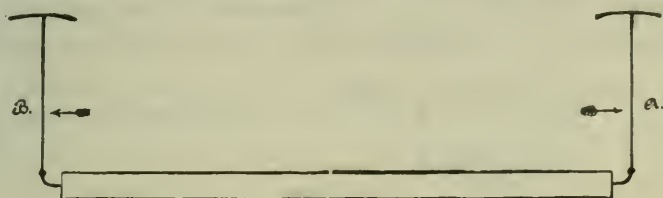


FIG. 5.

screw is taken. Precisely the same operation is then gone through with the measure that is to be compared, and the difference between the two readings of the micrometer screw then renders the difference in length between the two measures.

The support on which the measure rests is constructed in an instrument of this kind of two rules of different metals, one lying above the other and forming with it a Borda thermometer, similar to the standard metre described before. With the best instruments constructed on this principle, differences of the thousandth part of a millimetre can be measured.

Another form of comparator consists in a sensitive spirit level mounted on a strong brass plate, which swings around a horizontal axis. Through the brass plate passes a micrometer screw with a graduated head, the lower end of which screw is brought into contact with the upper end of the measure, this latter being placed in an upright position and its lower end resting on a fixed point at the bottom of the apparatus. After the standard has been placed into the described position, the screw is turned up or down, as the case may be, until the spirit level indicates the horizontal position of the plate, when the reading of the graduated head is taken. The measure to be compared is then treated the same way and the difference between the two micrometer readings renders the difference in length between the two measures.

A very ingenious construction of a reflecting comparator has been made by Mr. Saxton for the Coast Survey, and its main features may be described as follows:

While one end of the measure abuts against a fixed point, the other end, designated *A* in *Fig. 6*, is brought into contact with a small horizontal bar, *S*, sliding between guide pieces and being pressed lightly by a spring, in the direction of the arrow, against such end *A*. To the sliding bar are attached two arms, connected by a small chain which winds itself around a vertical axis, carrying a mirror *m m*. The bearings in which this vertical axis revolves

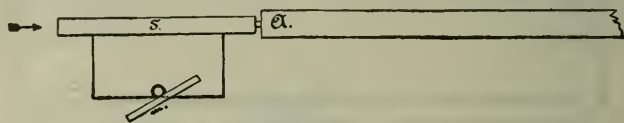


FIG. 6.

do not participate in the sliding motion of the bar, and the occurrence of such motion must, therefore, cause the mirror to turn with the axis to which it is attached. At a distance of about twenty feet from this apparatus there is a graduated arc of a circle, the centre of which is located in the vertical axis of the mirror. To the middle of this arc is attached a telescope, the line of collimation of

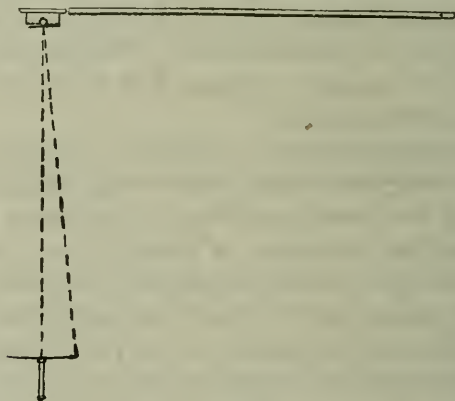


FIG. 7.

which is perpendicular on the direction of sliding bar and measure and passes through the axis of the mirror (see *Fig. 7*).

When the latter stands parallel to the sliding bar, then evidently the zero or middle point of the graduated arc will be reflected by it into the cross-hair of the telescope; any slight deviation from this position of the mirror will at once become apparent by another point of the graduated arc being reflected

into the cross-hair. From the difference of these reflected scale readings, the difference in length between two measures successively introduced into the apparatus is easily found, the limit of exactitude in the case of the Coast Survey instrument being the twenty-five thousandth part of an inch.

Line measures are compared by means of microscopes. Two of these, furnished with micrometers, are arranged as a beam compass, in such a way that the measure resting on its support can conveniently and exactly be moved into their focus. After the cross-hairs have been brought to coincidence first with the lines of the standard measure, the reading of the micrometers is taken and then the measure to be compared is introduced in the place of the standard and treated the same way. The difference between the two micrometer readings then renders the difference in length between the two measures. An apparatus of this kind in use at the Coast Survey building in Washington is arranged so that the bars are enclosed in a glass case during the comparison, the shifting and placing of them being done from the outside by ingeniously arranged levers, so as to avoid the influence of the heat emanating from the observer's body.

It is scarcely necessary to add that the successful handling of such instruments requires great experience and skill. To arrive at results as close as the small limits mentioned before is an exceedingly difficult and laborious process, during which numerous sources of error have to be carefully guarded against and which has to be repeated many times before the result is looked upon as well established. In this connection and in illustration of the great difficulties incident on the work of comparing length measures, some remarks may be quoted, made by Prof. Hilgard, late Superintendent of the Coast Survey, an acknowledged and widely-known authority. In the Coast Survey Report of 1876, he expresses himself as follows on the comparisons between the British Imperial and the American Standards :

"Extreme accuracy in this matter is beset with great difficulties, for in addition to that of ascertaining for each particular bar the rate of dilatation by temperature, there is an uncertainty in regard to permanence in the length of the bars themselves. Of the two Standard yards presented to the United States, one is of bronze (No. 11) and the other of Low Moor wrought iron (No. 57).

These are found to have changed their relative length by 0.00025 inch in twenty-five years; the bronze bar being now relatively shorter by that amount."

In further discussion of this remarkable fact, Prof. Hilgard says in the report of 1877 :

"When we consider the constitution of any bronze metal, especially such as Bailey's metal, from which, on account of its great rigidity, the British bronze standards were made, and which consists of copper, sixteen parts; tin, two and one-half parts; zinc, one part; we will observe the fact that about five-sixths of the mass is composed of copper, a very pliable and ductile metal, while the admixtures have imparted to it great hardness and rigidity. This alloy was especially selected for the latter mechanical qualities, but the suitability of the molecular structure was not considered. In the light of our recent experience, we are permitted to assume, that the molecules of such a casting are in a state of great tension, which will yield under changes of temperature, and, if so, perhaps in less degree, to the simple effect of continuance. Hence while we admit that the shortening of No. 11 bronze relative to the Imperial Standard has taken place in consequence of the great variations of temperature to which it has been subjected, it is not improbable that No. 1 and No. 6 (British bronze standards) may both have shortened by the effect of time alone during the past twenty years, so as to make the excess of No. 57 (wrought iron) a reality rather than an accumulation of residual errors."

Having now discussed in a cursory way the history of standard long measures, as well as various methods of their construction and comparison, it remains finally to inquire into the practical application of all this in our own particular case; that is, to cast a glance at the ways pursued in adopting and introducing a uniform measure of length in the United States.

A stranger, unacquainted with the subject and seeking information on the same, would naturally turn to any of the manifold and well-known hand-books containing formulæ, tables and other information daily needed by the engineer. Suppose, now, he would first chance upon Haswell, "*Mechanics' and Engineers' Pocket-Book*," edition of 1887, then he would there find upon page 44 the following information :

"English Imperial Standard is referred to a natural standard, which is a pendulum 39.1393 inches in length, vibrating seconds in vacuo in London at level of sea, measured between two marks on a brass rod at temperature 63°.

"NOTE.—In consequence of destruction of Standard by fire in 1834 and difficulty of replacing it by measurement of a pendulum, the present Standard is held to be about 1 part in 17230 less than that of the United States, equal to 3.67 inches in a mile."

Suppose that, not being satisfied with one authority, he consults a second one, and this time happens to select Trautwine's "Engineers' Pocket-Book," edition of 1887, then he will there read to his astonishment:

"By law, the United States Standards of length are made the same as the British."

Not being able to harmonize these two statements, he concludes to fall back upon an English authority, and chooses D. K. Clark's "Manual of Rules, Tables, etc.," London, 1884, where on page 186 he finds:

"United States. Length. The measurements are the same as those of Great Britain."

Suppose that our inquisitive foreigner now concludes to inquire for the actual standard and, being in New York, is shown to City Hall. There, on the north wall of the western corridor, at a height of about five feet from the ground, he will find two lengths of ten feet each, marked on the wall, one of them designated as English and the other as Amsterdam measurement. Above them are the words: "Federal measurement," with a blank space opposite left for the purpose of marking the length. Although this has not been done yet, the setting apart for it of a space at the side of the English Standard is certainly strong evidence of the fact that the two measures were considered different.

The matter now stands two against two, and our inquisitive friend will probably give up his hunt for the American Standard, being afraid that further investigation might involve him in further doubts.

As a matter of fact, the English author's statement is the only correct one, while the writer is sorry to say that our two countrymen are in error. American measure is not any longer than English measure, as Haswell states, but it is precisely the same.

Yet it is not so by law as Trautwine states, because, unfortunately, Congress has never passed a law to this effect. The salient historical points in this question may be summed up about as follows :

The Standard yard of Great Britain was lawful in the Colonies before 1776. By the Constitution of the United States, Congress was empowered to fix the standards of weights and measures ; it has, however, not made any use of this power as far as length measures are concerned, the only bills ever enacted on this subject being the following two : One approved of June 14, 1836, and empowering the Secretary of the Treasury to distribute complete sets of weights and measures to the different states, and one approved of July 28, 1866, legalizing the use of the metric system.

No new standard of length having been created by Congress to take the place of the old Colonial, that is, the British standard, this latter simply held over. The Coast Survey, in order to have a well accredited copy of it, procured the Troughton scale, and on the strength of Mr. Hassler's investigation, pronounced a certain part of it to be a standard at 62° F. When the comparison with the British government standards, received in 1856, had shown the Troughton scale to be too long at this temperature, then its standard temperature was accordingly corrected to $59^{\circ}\cdot4$ F. On the strength of subsequent comparisons, made about 1874, by Mr. Hilgard, at the British Standards office, the standard temperature of the Troughton scale was once more changed to $59^{\circ}\cdot8$ F., and after still further comparisons it is given in the Coast Survey Report of 1877, page 181, at $59^{\circ}\cdot62$ F., at which temperature the yard contained between the twenty-seventh and the sixty-third inch of the Troughton scale is so far finally stated to be exactly equal in length to the British Imperial Standard.

It is quite evident from all this that the intention has always been to entirely and precisely conform our measure to the English measure, and that the acquisition of the Troughton scale, and the adoption of a part of it as a standard simply were steps towards this end, steps which were modified as soon as they were found not to have exactly led to the object in view. But the comparisons leading to these modifications were only commenced after the Troughton scale had existed for many years as the undisputed

American standard, so that its character, as such, had become so firmly rooted in the public mind, that the difference found between it and the British government standard, appears to have been looked upon by many as a difference between American and English measurement. This at least, in connection with the destruction of the British Standard by fire, in 1834, and the difficulties incident on its exact reproduction, seems to be a probable explanation of the origin of an erroneous statement of facts, which as we have seen, has even found its way into the best books of reference. There can be no doubt, that all uncertainties and misunderstandings in the premises would have been prevented, and a perfectly clear and definite knowledge would prevail everywhere, if this important matter had been dealt with, as in other countries, by an explicit act of the legislative body, and it is to be regretted that this has never been done.

Such action, if it had included proper provision enabling private parties to obtain correct measurement, would have been exceedingly beneficial, especially to that large class of professional men for whom an accurate and trustworthy length-measure is amongst the most important every-day needs. At present, the engineer, for instance, desiring to test the length of his steel tape, has to be exceedingly careful not to be deluded by so-called standards, that are worthless notwithstanding a certain show of authenticity.

In the writer's own recent experience, he found three public standards in New York and Brooklyn at variance amongst each other so much as to make it unsafe to trust to any of them. In the very metropolis of this continent there was, therefore, no reliable official way of obtaining correct measurement, and the writer was compelled to address himself to the Coast Survey at Washington for this purpose.

A NEW CALORIMETER.

BY CECIL H. PEABODY.

The form of calorimeter here described was devised to determine the quality of moist steam, and introduced into the mechanical engineering laboratory of the Massachusetts Institute of Technology. Several other forms have been in successful use there, but this one appears worthy of notice on account of the simplicity of its construction and the ease of operation. Its action depends on the fact that the total heat of saturated steam increases with the temperature or pressure, and that consequently saturated steam becomes superheated when it is allowed to expand without doing work. If the steam is moist, the excess of heat at the higher pressure, above that at the lower pressure, is expended first, in vaporizing the water present, and second, in superheating the steam.

In the figure *A* is a piece of steam pipe six inches in diameter and ten inches long, capped at both ends. Into the caps are screwed the several fittings required. A half-inch pipe *a* brings steam to be tested; the branch *c* has a drip cock at the end to allow the water condensed against the sides of the pipe to escape, the branch *b* leads to the calorimeter, and is provided with a globe valve which is opened a fraction of a turn to admit steam to the chamber *A*. An inch pipe *d*, diagonally opposite the mouth of the pipe *b*, allows the steam to escape at a lower pressure; it is also provided with a globe valve by which the pressure in the chamber can be regulated.

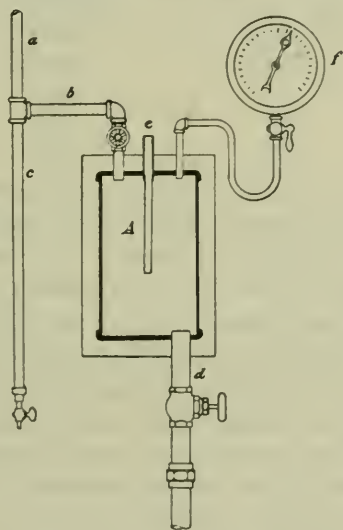
The thermometer cup, *e*, is made of a thin brass tube with the lower end closed, brazed into a thicker tube, which has a pipe thread cut on it, and which is screwed into the upper cap of the calorimeter with pipe tongs.

At *f* is a pressure gauge, which gives the pressure of the steam in the calorimeter. The pressure of the steam in the boiler or steam pipe from which the pipe *a* leads, should also be taken, pref-

erably by a gauge having a separate communication, but if the valve in the branch *b* is open only a slight amount, the gauge may be attached to the pipe *a*.

The chamber *A* is covered with asbestos board and hair felt, and may be enclosed in a case of sheet metal. The pipe *a*, the branch *b* and the valve in it are thoroughly wrapped with hair felt or other non-conducting substance. It is not necessary to wrap the pipes *c* and *d*.

To make a test, regulate the pressure in the chamber *A* by aid of the valve at *d*, so that the temperature shown by the thermometer at *e* shall be higher than that due to the pressure shown



by the gauge *f*. After the gauges and the thermometer have remained steady some minutes, note the pressures and the temperature, and also note the height of the barometer.

Let p be the absolute pressure in the steam pipe or boiler, and let q and r be the heat of the liquid and the latent heat of vaporization corresponding. Let p_1 be the absolute pressure in the chamber *A*, and let t_1 , q_1 and r_1 be the temperature, heat of the liquid and latent heat of vaporization corresponding. Let t_s be the temperature by the thermometer at *e*. Finally, let the mixture of steam and water in the pipe *a* be composed of x part of steam and $1-x$ part of water. The specific heat of superheated steam

is given by Regnault as 0.4805. Assuming that no heat is lost by radiation or changed into work

$$x r + q = r_1 + q_1 + 0.4805 (t_s - t_1)$$

$$\therefore x = \frac{r_1 + q_1 - q + 0.4805 (t_s - t_1)}{r} \quad (1)$$

and the per cent. of priming is

$$100 (1 - x) \quad (2)$$

The following table gives the results of several tests made in the Institute laboratory:

GAUGE PRESSURES.		Temperature Fahrenheit in Calorimeter.	Per Cent. of Priming.
Boiler.	Calorimeter.		
71.2	38.5	286.7	1.1
60.3	26.8	271.8	1.2
63.0	17.5	264.9	1.3
60.6	7.0	258.8	1.1
69.0	3.7	258.1	1.2

In the use of this apparatus the following precautions are to be observed, all of which, however, apply to any continuous calorimeter for determining the quality of steam. The boiler pressure and the pressure in the calorimeter must remain constant for some minutes before the test is made, so that the whole apparatus shall be at a constant temperature and neither receive nor give up heat save that taken from the steam to supply the external radiation. In this calorimeter no attempt is made to correct for radiation, but it is probable that the temperature of the steam in the centre of the calorimeter is not much affected thereby. The errors of the gauges and the thermometer should be known from recent determinations. It is to be noted that if the steam is superheated five degrees or more an error of two degrees in the temperature will have a very slight effect on the result. The gauges used should be divided to single pounds and should be compared with a reliable mercury column. The gauges on the market though sufficient for ordinary uses, are seldom accurate enough for this work, and they are liable to change during use. Unfortunately, a comparison of gauges with each other is of little avail since the errors vary irregularly.

The application of the calorimeter is limited to cases which have a small or moderate per cent. of priming. If the priming is

excessive the steam in the calorimeter will fail to be superheated. For any range of pressures the limit may be determined by a calculation similar to that of equation (1), making $(t_s - t_1) = 0$. Thus, with 100 pounds absolute pressure in the boiler and atmospheric pressure in the calorimeter, the steam will fail to be superheated if the priming exceeds four per cent. With lower pressures the limit is smaller and with higher pressures it is larger. If the pressure in the calorimeter is less than that of the atmosphere, for example, if the pipe *d* communicates with a condenser, the limit will be increased.

The calorimeter described is the first one made and it has been used just enough to show that consistent results can be attained. It is proposed to make others of different sizes and to make further experiments and comparison with other types of calorimeters.

CORRESPONDENCE.

THE IMPROVEMENT OF SABINE PASS.

To the Committee on Publications of the FRANKLIN INSTITUTE :

GENTLEMEN:—Permit me to add the following in reference to the improvement of Sabine Pass, in continuation of the correspondence in your number of May, 1888. Mine, of April 9, 1888, was not written with the purpose of questioning Prof. Haupt's veracity, its object was to correct a statement which, with its context, was entirely incorrect. I made objection to two items in the paragraph alluded to and repeated in Prof. Haupt's reply; the first item being the statement that the west jetty was built first, the second being that this west jetty had made a shoal on its east side.

With reference to the first, you are now informed that the perfect tense "was built" was not used to convey the idea of completeness. But Prof. Haupt quotes extracts from the history to support the expression that the west jetty was built first. He quotes the estimated cost of the entire work, \$3,177,606.50. The details of this estimate, as shown in the reports, gave the cost of the west jetty as \$1,412,493, and the reports further show that when the "work was commenced on the east jetty in March, 1885," only about \$300,000 had been expended in connection with the west jetty—not much more than one-fifth its estimated cost. I submit then that the phrasing "was built" conveyed a most unfair impression of the conditions to readers of the paper in your April number.

I pass on to the second item, viz: that this west jetty made a shoal on its east side.

I gather from the context in the paper in your April issue, that it was

intended to establish, in regard to this jetty at Sabine Pass, that it had arrested material moving along the coast from the east to the westward and thus made a shoal on the east of the jetty, and what I have to say is in controversy with that proposition, and I definitely assume that Prof. Haupt in his reply sustains the affirmative.

The shoal "opposite the Clifton, and extending from the jetty 1,000 feet east, upon which the depth had decreased from 0'6 to 1'3 feet since 1881," was not formed of such westward-moving material arrested by the jetty, but was formed outside or below the convex bend in the jetty of material scoured from inside of that point by the exit current from the Pass. This deposit was favored by the fact that the shoal existed there about the Clifton before the jetty was built at all, and by the additional fact that the portion of the jetty above that point deflected the exit current to the eastward of the locality. In the latter respect, the deposit was under similar conditions to the deposits usually made below the convex bends in a stream. The curve of six feet depth moved to the eastward some 800 to 900 feet with a deposit of "from 0'6 to 1'3 feet since 1881!" But the width across the channel, eastward, to the six-foot curve was 1,750 feet greater than before, a condition, I submit, incompatible with the formation of a shoal, made by the jetty on its east side, as stated in the proposition.

Prof. Haupt adds the second paragraph on page 412 to fortify the statement that the jetty made a shoal on the east side. He omitted to add the succeeding lines of the report; I will do so presently.

In 1884, previous to this survey by Mr. Raymond, efforts were made by parties desirous of promoting a gigantic contract for Galveston harbor to cast discredit upon all operations under the Corps of Engineers; unfortunately, they attacked the work at Sabine Pass. They assiduously reported that the jetty had been carried away during the winter; also that it had made a shoal on its eastward side in the following spring. They condemned "commencing" the west jetty first, and affirmed that it had actually caused a decrease of depth upon the bar by arresting sand coming from the eastward. Prof. Haupt brings *sand* from this direction, too. It was known that a deposit of this material had recently formed upon the bar. As the bottom to the eastward for miles was known to consist of *mud*, these people brought this sand deposit from Calcasieu Bar, the nearest point where sand is found. I had occasion to visit Sabine Pass in the early summer. This sand deposit was found by me upon the summit or crest of the bar very compact, and, at the time, it was quite evident that where the channel had been was then shoaler than ordinary. In the detailed instructions to Mr. Raymond, he was required to determine the limits of this sand deposit; this was an important part of the evidence in regard to its origin. If it came from Calcasieu Pass, it should have left a trail from that direction. Mr. Raymond reports as follows upon this the second point of his instructions:

"The general character of the bottom elsewhere than on the sand area is a very soft mud, the exceptions being a few hard mud areas of limited extent and a very few isolated spots where shell was found." Then follows the quotation given by Prof. Haupt, and the report progresses as follows:

"Its northern limit* is found in a depth of 6.5 feet almost uniformly, while its southern edge is nearly coincident with the nine-foot curve.† *These facts seem to show that this sand was brought out of the Pass* by the exceptionally strong currents of the remarkably high water period of last spring, and deposited immediately in front of the entrance to the Pass upon the beginning of the outer slope of the bar just where the current receives its first serious check in passing over the crest of the bar." Why should Prof. Haupt omit to quote the lines above, especially those I italicize?

I know from my own experience, that sand deposit was found previously on the crest of the bar, and the survey on the later date shows that it had moved seaward. And the channel over the bar was shown by the survey to have deepened somewhat since the survey previous to the commencement of the jetty, and that between the six feet contours it had widened 1,750 feet. All this is on the eastward of the jetty, upon which side your readers have been informed the jetty made a shoal.

Prof. Haupt's explanation of the immense shoaling on the western side is all in the line of a westward movement of material which the jetty arrested until the shoaling to the eastward formed a ramp up which the material was carried and deposited then to the westward of the jetty. I use the word "material" (Prof. Haupt said sand), for I make no point of the fact that the deposit is not sand, it is mud.

It is true that the *outer slope* of the bar had moved seaward. The large quantity of material excavated from the inner slope and from the crest, necessarily created deposits on the outer slope where the exit current decreased in velocity. That deposit was made upon the front of the exit current over the bar and necessarily then on the eastward of the jetty. Had the jetty been "built" on the east side, this deposit would have been on the west of it, and would have been *made by the jetty* in the same sense. All the curves defining the channel were pushed to the eastward upon their eastward side. Had the jetty made a shoal as stated, the westward-moving "sand" would have crowded these curves of depth toward the jetty.

In the early summer of 1884, I conducted a series of soundings along and upon the jetty. These soundings were made expressly in reference to the alleged disappearance of the jetty. The soundings were always greater on either side of the jetty than upon the jetty itself, and the indications were that there was an excavated trench on each side, as might be supposed from the alternating direction of the overflow currents. (I tried to learn whether a special set of littoral currents existed at the flood or ebb across the line of the jetty and to determine their direction, and instructed Mr. Raymond accordingly. Forty-two observations, distributed along the line of the jetty and beyond its end, were made, and at both ebb and flood the currents across the line of the jetty were to the eastward or westward, according to the direction of the wind, in every case. The resultant westward set of the flood, I think, must be quite weak at this locality, inside of the outer extremity

* That is, its inshore limit.—T. T.

† All on the outer slope of the bar.—T. T.

of the jetty.) Mr. Raymond's report says: "Along the edges of the jetty and immediately beyond the end, the deepening produced by cross currents has been from three to four feet." The deepest fill to the westward is along that portion of the jetty where the curve of nine feet depth is close upon the jetty and where it pushed seaward 2,150 feet. In fact, Prof. Haupt's ramp has only existed in imagination; I do not urge this as material to the issue, for the ramp theory may be dispensed with perhaps, now that the deposit is learned to be mud.

It would have weakened the force of the statement that "the crest of the bar had been moved seaward 1,900 feet" somewhat, had the report been quoted; "the crest of the bar, as determined by a line joining the points of the six-foot curve nearest together has advanced into the gulf 1,900 feet." But "the points of the six-foot curve nearest together" were 1,750 feet farther apart on this new "crest" than on the old, and the depth was greater; what had been the crest was scoured away.

There are several allusions in Prof. Haupt's reply, which seem to relate more particularly to his theory of harbor dynamics, and I pass them by without entering into controversy.

The context of the paper, "Jetties for Improving Estuaries," and his summary relative to Sabine Pass, most unfairly made it appear that a certain principle, condemned as vicious, had been there adopted and persisted in, and his statement was incorrect. I combat the incorrect statement. I have no intention of questioning his veracity; I should be exceedingly sorry to doubt it. I think, however, that his errors are due to haste, perhaps, also, to eagerness, which caused him to seize upon sentences without proper examination of their neighbors or due consideration of their relations to those portions overlooked.

I desire to add for the information of your readers that it is not and never has been the intention to bring about the improvement of the Sabine bar by the use of one jetty; the plan requires two high jetties. The work, while anyone may express condemnation of it in advance, must eventually stand or fall with its results.

Very respectfully,

THOMAS TURTLE,

Captain of Engineers.

WASHINGTON, D. C., May 21, 1888.

REPLY OF PROF. HAUPT TO CAPT. TURTLE'S COMMUNICATION
OF DATE MAY 21, 1888, RELATIVE TO SABINE PASS.

To the Committee on Publications of the FRANKLIN INSTITUTE.

Gentlemen:—In the reply of Capt. Turtle, he alludes to two of my statements, which he desires to correct, the first being that referring to the west jetty being "built first;" the second, that it had made a shoal on its east side. To these points I have the honor to submit a brief reply.

The difference of interpretation as to the use of the expression "was built" is not of sufficient importance to warrant the space devoted to it, since

the quotations show that at the time of Mr. Raymond's report, from which the extracts were made, the *east* jetty had not been begun, and whatever changes had occurred were due to so much of the *west* jetty as was then built. I used the verb in the proper tense, the past, not the "perfect," as has been stated. It was not intended to convey the idea of completeness. The verb itself does not mean this, but a progressive development.

In speaking of the present jetties, as they exist to-day, although *not finished*, I do not believe it would "convey a most unfair impression" to say they *were built*, as indicative of their existence, just as I used the term "*was built*," for the west jetty in its then incomplete state, to express *its* existence. Should any one assert that the jetties now existing at Sabine Pass were "*not built*," I think the statement would be at once denied as untrue.

Moreover, in recommending the jetties at Sabine Pass, the Board of Engineers said, "the western jetty as proposed by Capt. Heuer, should be *built first* (but without shore openings) and its effects observed."

The work was conducted accordingly, and I cannot understand the sophistry which would object to my use of the verb to build, and not to that of the Board.

(2) The fact that the west jetty made a shoal on its eastern side, will not be doubted after a reading of the reports of Mr. Raymond. It is not *my* statement which Capt. Turtle attempts to explain, but that of his own engineer, who says: "The line of deepest water over the bar has moved somewhat to the eastward by the formation of a shoal opposite the Clifton and extending from the jetty 1,000 feet east," etc. The point Capt. Turtle desires to make refers more particularly, however, to the direction of the movement of the material of which this shoal was composed, and he quotes some additional statements of *opinions*, and asks, "why should Prof. Haupt omit to quote the lines above," etc. In reply I would submit that my entire original reference to this work was of necessity very short, and the quotation I made covered but two lines. It was, therefore, impossible to say all that the report contained. I merely called attention to a few salient facts. The quotation from Mr. Raymond, which Capt. Turtle makes, is an *opinion* expressed in rather dubious terms, and not an observed fact, and as I did not endorse it, I did not quote it, for I believe the material of the shoal to have come chiefly from the eastward. (I used the term "sand," as Capt. Turtle has supposed, inadvertently, for material, although Mr. Raymond calls it sand.) The importance of the changes that are so minutely detailed in the reports will be better understood from the following statements of the character of the bottom as given in Major Howell's Report of February 4, 1875, containing this extract from a report by Lieutenant Smith, U.S.E., made as early as February 15, 1853:

"Although the charts represent the bar as having but a little over five feet at low water, yet, on account of the softness of the mud, a steamship can readily pass drawing ten feet. In case of a southeast blow, it would be safe to venture over with a draught of ten feet. It is asserted that a vessel drawing twelve feet of water has crossed the bar in a blow."

Again, in the plan proposed by Major Howell for improvement, it was intended that "the material * * be carried to the *westward* a distance of at least half a mile, and dumped in from six to fifteen feet depths, so as to form a ridge to cut off sand that may drift from that direction toward the excavation. It is thought that this channel may fill so slowly from material washed in from its *eastern* side as to only make occasional dredging necessary to maintain it."

What is the experience?

The report of 1885 says: "In 1878, a channel, 12 feet deep, was dredged across the bar; another was dredged in 1880; both soon refilled." * * "The amount of money spent * * aggregated about \$167,000."

These quotations show the recognized or suspected existence of littoral drift in both directions. It is not stated whether the cuts were filled by material from the Pass or from the adjacent shores, neither is it important. The fact remains that the material is very mobile, and that there is a lateral movement, the resultant of which I believe tends to the westward along this portion of the coast. It does not follow from this that violent southwest gales might not move sand eastwardly—to be returned by opposing storms.

That this sand would lodge on the outer or *up-hill* slope of the bar, if from the outside, rather than on the inner or down-hill slope, is natural.

My belief in this movement is founded upon such statements as these taken from Major Heuer's report of January 28, 1882:

"The bar at Sabine Pass is composed of a sticky, soft, blackish-blue mud to a depth of thirty feet." * * "The bar is probably a drift and wave bar and is certainly not a delta bar. * * * It is thought that the mud of which this bar is composed is eroded from the soft alluvial soil forming the coast for several hundred miles to the eastward, and is brought here by the wind waves and tidal currents. * * * We are, therefore, almost justified in stating that the bar is composed of soft mud to a depth of thirty feet below the water surface, as no traces of clay, sand, nor shell were found. * * * It was found that the flood tide in its first quarter, and sometimes extending nearly through its second quarter, came in on the Louisiana (east*) side; * * the current would frequently run out on the Texas side for two hours after the tide had commenced to run in on the Louisiana side. The ebb tides acted almost exactly opposite. The first of the ebb current was always on the Texas side," etc. * * * "Outside of Sabine Pass there is an undoubted littoral current whose general direction is from the east towards the west."

It would seem from these physical conditions that the conclusions as to a resultant westward drift are more than probable, and as it has been nowhere stated that a deposit or pocket of *sand* exists in the Pass or lake basin whereby to account for that found on the bar, the omission of a doubtful opinion as to its origin cannot have been a serious matter.

The references to the opposition of Galveston and to the trenches on both sides of the jetty, cut out by the cross currents due to the submerged condition of the work, appear to me irrelevant, and hence to require no answer.

The above quotations from Major Heuer's report do, however, appear to

sustain fully my "theory of harbor dynamics" to which Captain Turtle has alluded.

Respectfully submitted,

LEWIS M. HAUPT.

UNIVERSITY OF PENNSYLVANIA,

PHILADELPHIA, *June 7, 1888.*

REPORTS OF THE COMMITTEE ON SCIENCE AND THE ARTS.

THE BACHE SAFETY CAR HEATER.

[No. 1383.]

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, January, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

MR. R. MEADE BACHE'S SAFETY CAR HEATER,

Report: That the object of the invention is to provide a car heater that shall afford safety to the occupants of a railway car in the event of the overturning of the same. To accomplish this object, the inventor provides for the automatic extinguishment of the fire by means of water carried for the purpose in a reservoir forming part of the stove.

The principal features of construction are as follows:

The heater body is made of wrought iron, to insure ample strength against crushing, and its general form is that of a tubular boiler with a domed top.

The water reservoir forms an important feature, being firmly attached to the heater. The top is also fastened on by numerous screw bolts, and the orifice through which the water is admitted is closed by a disc which screws into the top. The whole is so firmly fastened that it cannot be detached without violence.

The smoke-pipe issues from a strong steel dome, and suitable provision is made to prevent the escape of coal from the smoke-vent, by a peculiar construction of the flue inside of the top of the heater. As an additional precaution, there is also provided a grating to receive the coal, placed inside the smoke-flue.

The door is strongly made, and of the same material as the heater body, especial care being bestowed upon the locking

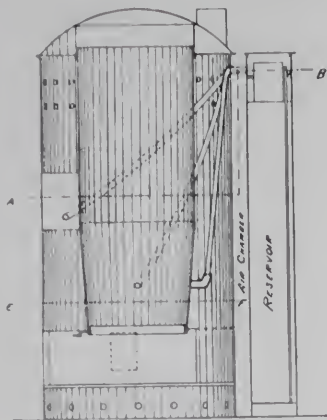
mechanism to assure ample security. The lock is so devised, as an added precaution, that the key cannot be withdrawn therefrom until the door is actually locked. The presence of the key in the lock will, therefore, be a "tell-tale," insuring, to a certain extent, the vigilance of the attendant.

For the purpose of extinguishing the fire in the heater in case of an accident, which would overturn it, a system of pipes is provided, one end of which terminates in the water reservoir, and the other end in and around the fire-pot. These pipes are suitably arranged in connection with air nozzles, that when the stove is overturned the water from the reservoir will be ejected through the pipes upon the contents of the fire-pot, and will promptly extinguish the fire therein.

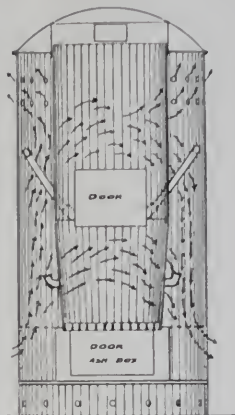
Around the bottom of the heater, with its base at the level of the ash-pit floor, is placed a flue running about the periphery of the heater. The ash-pit sides form its inner side, the outside casing of the heater forms its outer side, and its top and bottom extend across the space between the outside and inside casing of the heater. This flue is perforated all over the top with numerous small holes, to allow of the free passage of air through them. At the middle it is divided by a diaphragm. Air is received into the flue in the usual way, from the outside of the car, through one of the large openings in the base of the stove. Through the movement of the cars, the air is forced through the flues and warmed in its passage, and is distributed about the car by the ordinary channels along the side of the same. Between the heater body and the reservoir there is an air space, through which a portion of the cool air entering the flue is permitted to pass, thus maintaining a circulation of air which prevents the water in the reservoir from becoming unduly hot.

The above comprises the essential features of Mr. Bache's safety heater, and for additional details the Committee refers to a more elaborate description furnished by the inventor, which is attached to this report.

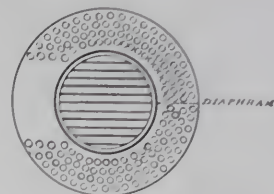
The Committee has had the opportunity of witnessing some experiments upon a full-size heater, of the form herein described, which satisfied the members of the substantial accuracy of the inventor's claims respecting the promptness and effectiveness of its fire-extinguishing qualities. In these experiments, the heater



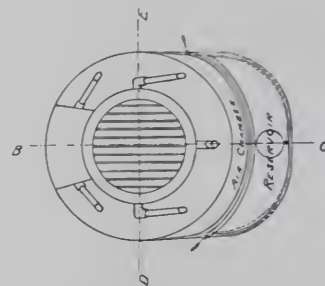
Section on line, B.C.



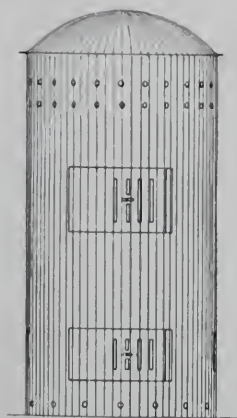
Section on line, D.E.



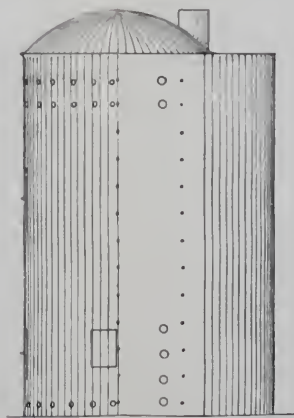
Section on line, E.F.



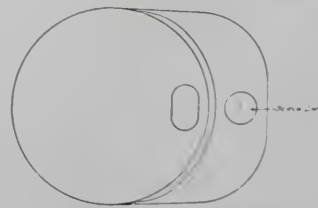
Section on line, A.B.



Front Elevation.



Side Elevation.



Plan, looking down on Top.



was violently thrown upon its side, after a bright fire had been made in it, and the fire was entirely extinguished in less than one minute.

The Committee desires to give the applicant full credit for the very careful and thorough manner in which he has worked out each detail of construction. The car heater which he has produced, in the Committee's opinion, is distinctly superior to the car stoves in general use, in respect to safety, and it appears to be admirably designed and constructed to answer its intended purpose.

The Committee is aware that experiments have lately been made with the view of employing other means than direct fire for the heating of railway cars, and in passing judgment on this invention, does not wish to discourage them. So far as the Committee is advised, these trials have not passed beyond the experimental stage. It is well known to railroad men, also, that there are many circumstances and situations where systems of direct firing will have to be retained, even should the heating of railway cars by steam be made practically successful. The Committee commends the invention of Mr. Bache as highly meritorious.

CHAS. J. SHAIN,

CHAS. A. RUTTER,

RUFUS HILL.

Adopted April 4, 1888.

GEORGE A. KOENIG, *Chairman.*

APPENDIX.

DESCRIPTION OF A SAFETY CAR HEATER, DESIGNED BY R. MEADE BACHE.

[*Read before the FRANKLIN INSTITUTE, by Mr. BACHE, May 18, 1887.*]

Various devices have been suggested for safety car heaters—so-called chemical, and so-called automatic, arrangements—the former kind occasionally, the latter always, entering into the plan. It has seemed to me that water is the most reliable thing for the extinguishment of fire, and that a truly automatic and trustworthy arrangement could be combined with the use of water, if one could

dispense with the use of valves. Upon that basis, therefore, having dispensed with valves, I proceeded.

A large amount of water is not needed for extinguishing so small an amount of fire as that which can be contained in a car heater: less than a cubic foot suffices. In consequence, I settled upon a size of reservoir which should contain about three cubic feet of water; one for extinguishment of fire, the others to give sufficient head for the water. The steam generated by so small an amount of fire as that which can be contained in a car heater reaches the open air in the form of harmless vapor, similar in temperature, within a foot of its egress, to that of a Russian bath. Neither in quantity nor in quality can it be deemed even unpleasant.

The material adopted for the car heater designed by me is boiler iron, of the thickness of an eighth of an inch. The form of the apparatus is tubular, with a domed top. The top itself is of steel. This premised as to the general character of the heater, it remains to speak of the details of its construction. The doors are made of the same kind of material as that in the rest of the apparatus. They do not, when shut, depend for security upon the hinges on which they conveniently swing when open. They fit into the door openings as, in a general way, do those of fire-proof safes, and they are locked, in a general way similarly, by bolts of the height of the doors. The locks are fundamentally like those of combination locks; that is to say, there is a slot in a circle of metal into which the bolt fits; only, whereas in the combination lock there are many slots, in this case there is but one. The keys cannot be withdrawn unless the doors are actually locked. This precaution covers the contingency of neglect on the part of attendants to fasten a door, and puts it out of the power of passengers to open it.

The reservoir forms an integral portion of the heater itself, being firmly fastened to the heater, and having its top secured by numerous screw-bolts; and the orifice on top through which water is supplied to it is closed by a disc which screws into the top.

The smoke-pipe vent issues from a strong steel dome; and whereas ordinary smoke-pipe vents come directly outward from the heater, making, in fact, doors from which coal might escape, it is impossible for coal to escape from the smoke-pipe vent of this

heater, on account of the peculiar construction of the flue inside of the top of the heater. The floor of this flue lies between the outside and inside casings of the heater, its inner side is the continuation of the inside casing of the heater, and its other side, and top as well, are formed by the curve of the dome. The products of combustion enter the flue on the inner side, then pass in both directions around the flue, and then, exactly opposite where they enter, are liberated through a smoke-pipe passing vertically through the top of the dome. Therefore, for coal to pass through this flue to the outer air, it would be requisite, first, that the apparatus should stand on its head, that it should then, after falling to the horizontal position, receive a rotary motion around its axis, and finally, that it should, exactly when the coal had reached a position opposite the pipe-vent orifice, stand on its head again. An extra precaution has, however, been adopted to guard against this nearly impossible concatenation of circumstances. This consists in placing a grating in the smoke-flue, on both sides of the vent from the heater, so that whatever lodges there must stay there.

There is another factor noticed, but not yet fully described, included in the safety of the heater—that involved in its capacity of self-extinguishment. It may here be asked if it is not illogical to claim that a receptacle will, although subjected to violence, retain its fire, and yet to admit that it ought to include in its construction the capacity of self-extinguishment. It would be illogical if one should claim that under all circumstances a heater would retain its fire, but no such assertion is made here. The answer to a question which implies that such an apparatus must be so constructed as to enable it to resist the shock of any railway accident, is that railways themselves, cars and everything else included in them, are not so constructed. Nor, it may be added, is anything that man uses, even when his object incidentally contemplates resistance to force, so constructed that it can resist any force whatsoever of his accidental or designed creation. The weapons of a steel-clad knight, although primarily intended to be offensive, helped, in their defensive capacity, to guarantee the integrity of the mail itself. So, of a car heater, one may justly hold that it cannot be proof, through mere strength, against any possible railway accident, and yet that the water which the apparatus will throw in the

midst of an accident too severe for strength to avail may prevent the catastrophe of fire.

The nozzles of certain pipes, as may be seen from the model of the heater, enter the fire-pot itself. The nozzles of other pipes, as may also be seen, guard the door. The jets from the nozzles of the first set of pipes strike the fire in the very centre, and the jets from the nozzles of the second set of pipes strike the fire on top.

The upper system of air-tubes, on top of the reservoir, supplies the reservoir with atmospheric pressure through the 180° through which the apparatus may depart from the upright vertical position; and also supplies it with atmospheric pressure in any horizontal position which it may assume. As, on the contrary, when the reservoir is full, and the apparatus is in any position more or less upside down, through the other 180° of the circle, the upper system of air-tubes is incapable of acting as air-tubes, in those positions the single lower air-tube rising from the bottom of the reservoir supplies the place of the upper system.

Around the bottom of the heater, with its base at the level of the ash-pit floor, is a flue; continuous, but for the place where the ash-pit door comes, around the periphery of the heater. The ash-pit sides form its inner side, the outside casing of the heater forms its outer side, and its top and bottom extend across the space between the outside and inside casings of the heater. This flue is perforated all over its top with minute holes, so as to allow of the free passage of air through them. Finally, it is divided in the middle, at the rear, by a vertical diaphragm. Air is received into the flue in the usual way, from the outside of the car, through one of the large openings near the base of the heater; and through the propulsion of the air in its rear, from the movement of the car and from the rarefaction of the air entering the heater, the air in the flue up to the dividing diaphragm rises through the perforations on top of one-half of the flue into the space between the outside and inside casings of the heater. It then descends, after being heated between these casings, propelled through the perforations on top of that half of the flue which is beyond the diaphragm, and reaches, through the other large opening near the base of the heater, the ordinary channel which conveys it for warming purposes along the side of the car.

There is an air space of two inches between the heater and the

reservoir. A line of small holes, near the bottom of the side of the heater, on the cool air side of the lower flue, enters this air space. Therefore, when cool air is driven into this space by the motion of the car, a portion of it maintains a circulation of air between the reservoir and the heating part of the apparatus.

On top of the reservoir is a telltale indicating if the level of water has been allowed to become too low for the full effectiveness of the apparatus.

Just within the top of the reservoir is a diaphragm checking wave motion and indicating the height to which the reservoir should be filled.

Aside from the element of safety in this heater, and with reference now solely to its convenience for warming purposes, it may properly be stated in its favor that, whereas the present car heater discharges a large amount of heat from its sides, this one discharges relatively more from its top. This is an advantage in a car heater, as every experienced traveller will concede.

Inasmuch as the best heating for the purpose of bodily comfort and health consists in the delivery of a large volume of air drawn from a pure, outside source, and heated in transit, we have in a properly-constructed car heater, with hood and conduit for air and with vertical and lateral radiation properly adjusted through the mechanical means of a deflecting plate, the ideal of a heating apparatus for ordinary railway needs, each car commanding its own supply of heat at pleasure. Heating by waste steam from the engine is applicable to railways only within circumscribed limits. The general car heater must be constructed upon the plan of the past, so far as heating is concerned, but with the element of safety superadded to its convenience.

ZIEGLER'S PATENT TRESTLE AND SCAFFOLD SYSTEM.

[No. 1397.]

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, May 2, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination

GEORGE W. ZIEGLER'S PATENTED TRESTLES AND SCAFFOLDING SYSTEM,

Report: That they have examined the same and find that the invention consists in a metallic clamp adapted to embrace and

securely hold together the wooden portions of such structures, the legs and horizontal beam, and, without cutting away any portion subjected to the load, or impairing the strength of the wood, firmly holding the parts in correct position with each other.

This invention is the subject of United States Letters-Patent, numbered 318,154 and 362,914, dated, respectively, May 19, 1885, and May 10, 1887, the latter patent being for attachments to the former, rendering it applicable to the easy erection of secure platforms, stages and tables, and other structures intended for temporary use, and required to be compactly stored and conveniently transported and re-erected.

A third United States patent, numbered 327,427, and dated September 29, 1885, is for a modified form of the first; applicable to the building of temporary bridges and high scaffolds.

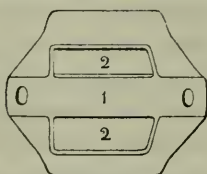


FIG. 1.

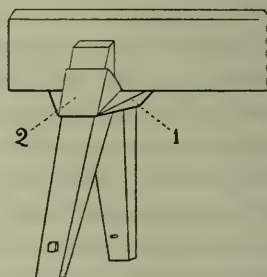


FIG. 2.

In addition to these patents, the inventor has also seven other patents, and applications for some others in course of preparation, for devices, embracing adaptations of his clamping inventions, to uses in articles of furniture for domestic purposes and stagings for accommodating public meetings. It will, therefore, be seen that the inventions are really a system of structures depending upon and embodying the clamping device, which we will now proceed to describe.

This consists in a band or socket, shown in the adjacent *Fig. 1*, having a flat bearing, 1, on which the horizontal beam, shown in *Fig. 2*, rests on converging sockets, open at the upper end, into which the legs of the trestle are inserted. In making these sockets, the properties of the material (malleable cast iron) have been carefully studied, and all abrupt, sharp, internal angles and thick places or parts avoided. It is well known that the interior metal of thick

parts in malleable castings does not contribute to the strength of the casting, but by shrinking or contraction weakens it. This shrinking occurs when the metal is first cast and is extremely hard and brittle. The ductile or malleable properties of the casting, being developed by subsequent treatment, do not mend the checks and cracks that form in the casting operation.

The wooden parts of the trestle are simply inserted in the sockets or clamps and are there held without recourse to other fastenings. The dressing or fitting required in the wooden parts is merely to cut one inclined surface on the side of the leg to rest against the beam, and to cut the base of the legs to a horizontal plane; all of the wood remains intact in the legs between

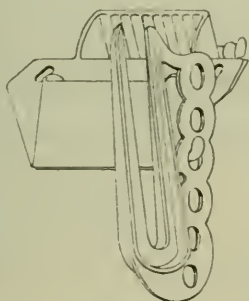


FIG. 3.

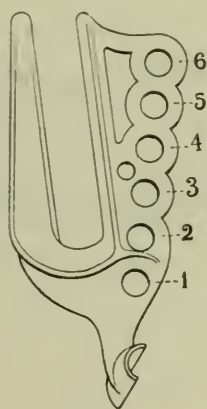


FIG. 4.

the socket clamps and the base, and all of it is efficiently used in sustaining the load.

These clamps are made in a variety of sizes adapted to different classes of work.

To some of the clamps are attached hooks, shown in *Fig. 3*, upon which a bracket, shown separately in *Fig. 4*, provided with a series of apertures at intervals of an inch, and slots open at the top of a width equal to the thickness of the boards used in flooring. The edges of the slot are bevelled, so that they impinge on the sides of the board; each of the apertures is numbered, so that by hooking the aperture with the number corresponding with width of the board, the boards placed on edge in the brackets

present their upper edges the same in the same plane as joists to support a flooring.

The trestles, made as described, are susceptible of assembling into bridges, as shown in *Fig. 5*, or as a scaffold, as shown in *Fig. 6*, which can be extended indefinitely in length and height, and may be braced by means of bracket-hooks, as shown in *Fig. 6*.

This form of the invention, as above described, has the following advantage over other systems of scaffolding : It utilizes the entire strength of the material ; does not suffer any waste in taking down and re-erecting ; is compact and convenient for storage or transportation ; does not depend on the skill of workmen for its safe proportioning and proper erection ; and the clamps being the

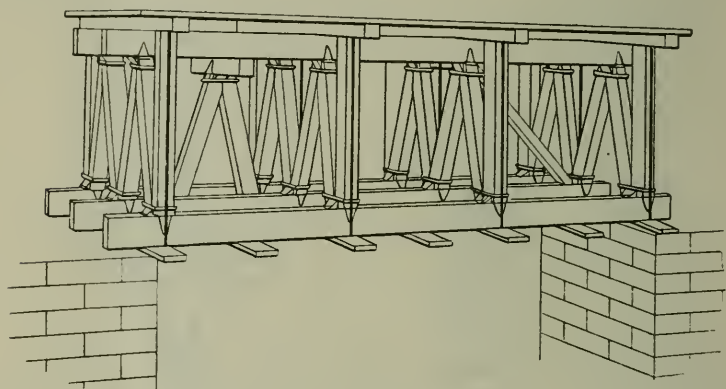


FIG. 5.

only parts requiring to be made from patterns in special factories and transported long distances, the invention can be used economically wherever sawed lumber is procurable ; and, since by their form, they determine the angle of inclination of the parts of the wood-work to insure proper bracing effects, correct work in this important feature is enforced.

In another form of the trestles made by the same inventor, a different system of construction is involved ; this is shown in the blue prints annexed to this report, and consists of plates having projecting spurs which imbed themselves in the sides of the wood forming the beams and legs, and the plates are fitted so as to turn upon each other and permit the legs to fold in parallel position

with the beam, the parts being united by bolts passing through washers embracing the width of the leg strips, and provided with spherical seats against which the bolts and nuts hold, thus avoiding all other strain on the bolt than that of tension in the line of its axis. A test carefully made by the Bureau of Steam Engineering of the United States Navy shows the value and capacity of the invention for sustaining weight, a report of which is submitted with other documentary evidence.

The development of the invention, as shown in its application to various uses in domestic arrangements as well as in the arts, is

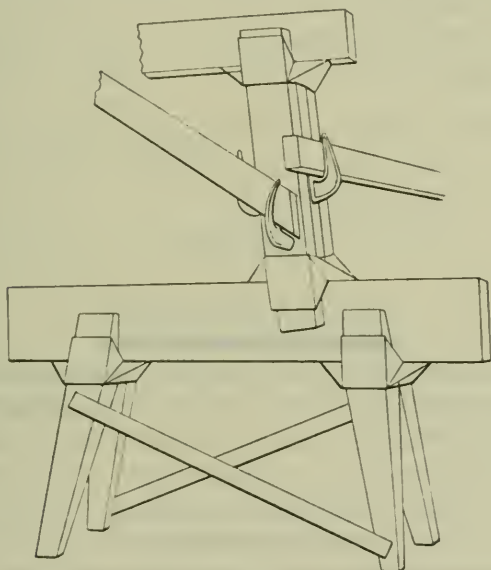


FIG. 6.

so fully shown in the patents and drawings appended that your Committee does not feel warranted in incorporating such a mass of detail in this report, but simply refers to the patent specifications and documents hereto annexed and named in an appended schedule.

Although it is generally well known that scaffolds have been made which were adjustable to different situations, and in which clamps were used to unite the sections of the uprights and braces, it does not appear that in any of them the bracing and clamping effects were attained by sockets embracing the different parts at their joints.

In conclusion, your Committee feels fully warranted in stating that the system of trestles and scaffolding submitted by Mr. Geo. W. Ziegler is deserving of recognition as of great merit, in that it economizes material, produces safe scaffolding structures easily procured wherever building materials are accessible, offers an effective means of diminishing the waste of lumber that has prevailed in building operations, and is susceptible of easy and immediate introduction in the arts, without specially training of workmen to accustom them to its use, and, upon its merit, justifies the recommendation of the award of "THE JOHN SCOTT LEGACY MEDAL AND PREMIUM."

S. LLOYD WIEGAND, *Chairman*,

GEO. W. WILSON,

H. R. HEYL,

FRANK P. BROWN.

Adopted June 4, 1888.

GEO. A. KOENIG, *Chairman.*

OBITUARY.

HENRY CARVILL LEWIS.

Prof. HENRY CARVILL LEWIS, who was connected with the faculty of Haverford College and with the Professorship of Mineralogy of the Academy of Natural Sciences, died in Manchester, England, on July 21, 1888, of typhoid fever. This sudden termination of a most promising and bright career is inexpressibly sad.

Prof. LEWIS was devoted to science for science's own sake, and added to the high ambition of conquests in the field of original research a singleness of purpose and an industry which are given to but very few, even of those who choose the Laufbahn of pure science. His work, in connection with the glacial geology of Pennsylvania, and the post-tertiary history of the neighborhood of the city, will remain, in the published volumes of the Second Geological Survey of Pennsylvania (C_5 , C_6 and Z), as enduring monuments to him. His interest in the questions which the modern method of microscopical lithology has raised was profound, and if his life had been prolonged he would assuredly have taken rank with the more prominent American petrologists. As a professor his energy and enthusiasm was infused into his pupils, few of whom, however indifferent at

the outset, could resist the influence which he exerted. His field rambles with his classes were always looked forward to by the participants with pleasure and always well attended.

He was the first to bring before the Academy of Natural Sciences, in 1883, the proposition to hold a joint meeting of the British and American Associations for the Advancement of Science in Philadelphia during September of the following year, and as one of the local secretaries of that meeting he contributed largely to the success of the undertaking. His lectures and expositions in learned societies were always characterized by clearness and fluency to which an agreeable voice and a fine presence lent force.

He was one of the early members of the Mineralogical Section of the Academy of Natural Sciences and one of the most valued contributors to its work.

During the last few years Prof. LEWIS studied in Germany, and it was his intention to take part in the proceedings of Section C (Geology) of the B. A. A. S. at the meeting in Bath, England, as well as to attend the meeting of the International Congress of Geologists in London shortly afterwards.

His loss is sincerely mourned, not only by scientific men generally in this country, among whom he held an honorable place, but by the wider circle of friends and acquaintances to which he was known chiefly as a cultivated and earnest promoter of many forms of educational progress.

PERSIFOR FRAZER.

WILLIAM HELME.

Mr. WILLIAM HELME died at Strafford, Pennsylvania, on June 12th, from the effects of a severe stroke of paralysis received on the morning of June 3, 1888.

Mr. HELME was born in Dumfries, Scotland, on the 25th of April, 1824, and when a child accompanied his parents to this country, settling in Philadelphia.

He learned the trade of machinist in the shops of the Baldwin Locomotive Works, and whilst there was offered the position of Superintendent of the Gas Works at Trenton, N. J., which he accepted, this being his introduction to the business which he most directly followed during the remainder of his life. Later he completed the erection of the gas works in Augusta, Ga., and remained

there sometime as Superintendent. In 1853, he resigned the position and associating himself with two prominent citizens of Augusta entered the lumber and saw-mill business.

A site was secured at Brunswick, Ga., and on it they erected the largest saw-mill then in the South. This venture proved disastrous, as but three months elapsed after the completion of the mill when it was struck by lightning and entirely consumed by fire. It was never rebuilt and the old stack was a well-known landmark in the vicinity until within the past few years. After this misfortune, he returned to the gas business and secured the contract for the building of works at Winchester, Va., and after their completion he constructed works at various places in Pennsylvania and the South.

In 1856, he built the works at Atlanta, Ga. These works were rebuilt immediately after the war, having been almost entirely destroyed by General Sherman's army.

To these works Mr. HELME gave most of his attention, having held from the beginning the largest individual interest in them. He ably guided the company through many trials, and five years ago successfully solved the problem of dollar gas, continuing to pay fair dividends without interruption; and his careful management leaves the company in a stronger position at present than at any other period of its history.

In 1865, he became interested in certain mining operations in Arizona, and went there to erect the machinery, etc. This was before the days of railroads west of the Missouri, and he went to Arizona, and continued on to the Pacific on horseback.

On his return from the West, he engaged with the firm of A. Whitney & Sons, car-wheel manufacturers, in the position of Superintendent, and continued with them until 1872, when he entered the firm of Harris & Brother, manufacturers of gas-meters, which firm was succeeded by that of Helme & McIlhenny, in which he was senior partner at the time of his death.

Mr. HELME combined the sterling and conservative qualities of his native land, with the activity and business energy of the country of his adoption.

He was an active member of the American Gas Light Association from its formation.

He was, at the time of his death, one of the oldest members of

the FRANKLIN INSTITUTE, having been elected in 1844, and was and had been since the year 1860 a member of the Board of Managers. At all times he manifested a lively interest in the affairs of the INSTITUTE, and rendered valuable service upon its Committees.

He was a member, and for some years the President, of the St. Andrew's Society of Philadelphia; a manager of the Hayes Home for Aged Mechanics, and was identified in an unobtrusive way with other benevolent and charitable institutions.

ISAAC NORRIS, M.D., EDWARD LONGSTRETH, WM. H. WAHL.

SCIENTIFIC NOTES AND COMMENTS.

ENGINEERING.

NATIONAL PUBLIC WORKS.—The proposed legislation, having for its final aim the combination into one department of the entire scientific work of the Government, is worth more than a passing notice from those who are not interested in the matter, either as civil engineers looking for Government work, or those in the Government employ interested in retaining in their control the technical work done by the different bureaus of the different departments of the Government. As an entering wedge, the Council of Engineering Societies on National Public Works has had bills introduced in both Houses of Congress to establish a Bureau of Harbors and Water-ways under the War Department. As this bureau is to be the basis or nucleus of the new department, the bills are interesting. This council is composed of representatives from the various engineering societies in the United States, representing over 3,000 members. There is no doubt but that the sentiments of this council are the expressions of opinions generally entertained by civil engineers, but in this 3,000 men there are many who are not civil engineers, and who have probably not, except in a general way, given the matter any attention. Representation of a society at a meeting of a council of this kind is generally brought about in this way. An invitation is sent to an engineering society, composed of, say, 200 members, to send a representative to the meeting of the council. It is read by the secretary at the next meeting of the society, at which, say, thirty members are present. A member is appointed to represent the society, and at the next meeting of the council the society is represented *by proxy*, and 200 more civil engineers are in complete accord with the views of the council.

In a pamphlet, published March, 1888, the aims of the council are set forth in the following paragraph:

"It is proposed to create a system which, while securing thorough administrative responsibility, will at the same time utilize, without repression, all the brains of the personnel—a system, the vitality and usefulness of which is the aggregate expression of the corps rather than of its chief."

The methods by which this is to be done are set forth in the bill, a synopsis of which is given later. The working of the scheme will be often like the following: A. B., Assistant Engineer, in charge of the work at X. Y., finds that certain changes in the methods used (which were originally formulated by a clerk in the office of the Department Engineer) would facilitate work, and sends a communication to C. D., Resident Engineer, stating proposed changes, giving cost, etc. C. D., knowing the nature of the work done, approves of A. B.'s recommendations, and refers the communication to E. F., Division Engineer. E. F. forwards to the Department Engineer, who knows that C. D. is not much of an engineer anyway, and has never heard of A. B., who is not an officer, and, of course, cannot know as much as his clerk, and the recommendations are not approved, and thus the brains of the personnel are utilized. It is not at all likely that the new arrangement will be as successful as the present one in taking advantage of the recommendations of those actually engaged in the work.

While the council wisely remarks that "in great engineering enterprises it is prerequisite that the chief shall not only be an able man, but shall have had a preliminary training and an actual experience in the details which he is called upon to supervise," it does not follow that the chief of this new department will have to be such an officer. While it still remains a bureau, there will be many technical questions which he will be called upon to finally decide, and which will be decided and the work finally carried out as indicated by one man, which is to be deplored (see first quotation); but upon reaching the dignity of a department, the chief need no more be a civil engineer than the Secretary of War need be an expert in ordnance or the Secretary of the Navy in ship building.

Great stress is laid upon the fact that the ranks will be recruited from men of special education, such as is now provided by several engineering schools. This is curious, in view of the work done at the Military Academy and at many of these schools. Anyone aware of the amount, and especially the quality of the work done at the different institutions, would never for an instant attempt to make a comparison, as the work at the Government schools is far in advance of that done in all but one or, at most, two of these engineering schools. As far as technical knowledge of the kind necessary for use in river and harbor work goes, where is there a corps of instructors better fitted to teach it to-day than at West Point? and where are students graduated from any institution with a broad knowledge of engineering who are any more capable of doing this work than those graduated at West Point?

The fact that the engineers of the army are well fitted, both by education and training, for the work they have to do, is admitted in the proposition to transfer bodily one-half of this corps of the army to the corps of civil engineers. It therefore seems somewhat contradictory to talk in one place of special training, which by inference engineers of the army do not have, and in another to admit that one-half the corps would be transferred and "none need be disbarred."

The council also says, that "under a well ordered system, requiring sev-

eral tests for fitness and experience, none but deserving men will reach the grade of division engineer."

It cannot be believed that any system of examination will exclude non-deserving men from promotion, and where promotion is principally by seniority (after examination), it will be found nearly impossible to get rid of an incompetent man. Incompetence is about as hard a charge to *prove* against a man, before a court composed of his associates and many times his friends, as could be preferred against him, and it is doubtful whether more dismissals would be made for this cause than now take place in the army or navy for the same cause, and the new corps being recruited from the graduate of engineering schools would undoubtedly have far more of this class than either the military or the naval services. At present, when a man has shown his incapacity for the work he is doing, a simple order from the Department is issued, and he no longer is employed on the work. Under the new scheme he would continue expending Government funds until he retired, or is put upon half pay.

The provision allowing the employment of expert engineers outside the new corps is surely unnecessary. A body of eminent men, especially trained in river and harbor work, using all the brains of the personnel, could hardly need the assistance of the few civil engineers of experience in river and harbor work who would be left in civil life after the 600 are members of the corps.

While the present bill would take care of many engineers now out of the Government employ, at the end of one generation the present condition of affairs would again exist, and the new generation of civil engineers could, with as good grace, and would make the same charges of incompetency and prodigality against the Corps of Civil Engineers that are now made against those engineers at present in charge of the work.

The council has evidently taken it for granted that there is but one best way of carrying on the great operations of the governments of all countries, and that if the best parts of the systems of other countries be formulated into a general plan it will be the best one for this country. Until political advantage and the public good are synonymous terms, any plans based upon the latter solely must give way for the former.

While there is no question but that improvements can be made in the methods of improving rivers and harbors, it would be well to be sure that proposed changes will probably result advantageously before making them. The proposed legislation will undoubtedly result in advantage to the civil engineers, but what advantage can result to the country or to the work to be done is not so clear.

The following is a summary of the bill as recommended by the Council :

SECTION 1 provides for the establishment of a Bureau of Harbor and Water-ways under the War Department, to be officered by the Corps of United States Civil Engineers.

SEC. 2 defines the limits of the work of the Bureau.

SEC. 3 provides that no appropriation shall be expended on a work unless

it is enough to complete it, or unless provision shall have been made for funds. Appropriations are to be available until used.

SEC. 4 provides for reports and financial statements.

SEC. 5 allows Secretary of War to do work by contract under certain restrictions.

SEC. 6 provides for personnel:

Officers.—1 chief engineer, 4 associate chief engineers, 11 department engineers, 50 division engineers, 100 resident engineers.

Not officers.—200 first assistant engineers, 250 second assistant engineers.

SEC. 7. Officers are to be appointed by the President by and with the consent of the Senate. All except chief are to be appointed after examination. First and second assistant engineers are to be appointed by the Secretary of War.

Every third vacancy in first assistant, fifth in resident and tenth in division engineers may be filled from outside the regular service (after examination).

SEC. 8 Promotion by seniority after examination. Seniority determined by date of commission or appointment.

SEC. 9 gives Secretary of War power to determine number of vacancies to be filled by appointment or promotion, and practically gives him power to institute inquiry and trial courts.

SEC. 10. Pay.—Chief engineer, \$10,000 (pay of army officer of least rank allowed to do the work, \$5,220).

Associate chief, \$7,500 (\$4,736).

Department engineer, \$6,000 (\$4,036).

Division engineer, \$4,000 (\$3,232).

Resident engineer, \$2,700 (\$2,376).

First assistant engineer, \$1,800.

Second assistant engineer, \$1,200.

Secretary of War also allowed to employ special engineering counsel and engineers to do the work of first and second assistant engineers temporarily.

SEC. 11. All officers retire at sixty-five years of age on half pay.

SEC. 12. Members of this corps are not to be employed upon work outside the Bureau except on the President's orders.

SEC. 13 provides that in establishing the corps, the engineers of the army may be assigned in certain proportions and fixes their rank.

SEC. 14 provides for the return of these officers to the army work or permits of their permanent membership of the new corps.

SEC. 15 provides for a commission to formulate rules and regulations, and to nominate officers.

SEC. 16 provides for the division of the country into departments.

SEC. 17 provides for annual reports on the needs of the country.

SEC. 18 provides for temporary retirement on half pay of those not actually needed, and allows officers *so retired* to accept outside professional work.

SEC. 19 provides for estimates.

SEC. 20 repeals conflicting statutes, and vacates and abolishes all other offices than those provided for.

H. W. S.

THE REORGANIZATION OF PUBLIC CIVIL WORKS.—The Cullom-Breckinridge Bill for the reorganization of the civil works of the Government, in connection more especially with the river and harbor improvements, has been introduced in both the Senate and House of Representatives, read and referred to their appropriate committees. The measure is one of great national importance, since the present method of conducting our civil works is one which has grown up with the development of the country, and is not even based upon a fixed organization. It is open to serious defects in the methods of securing the appropriations for urgent works, insufficient funds to complete them rapidly or to maintain them after having been commenced, lack of responsibility for methods and results, frequent changes in the personnel of the corps and, in times of war, there may be a total suspension of all work.

There is no public improvement that we can imagine of greater benefit to all classes of individuals than that of improving the water ways, whereby the cost of transportation may be completely controlled and the market range of either raw material or manufactured product be extended. To promote these benefits and remove these defects is the object of this bill, and yet the conservatism of the existing régime is heard protesting against it in the interest of a method which pours out the public funds for work which must soon be rebuilt, because not protected, and places the public patronage in the hands of politicians.

There is no charge nor implication of dishonesty nor incompetency on the part of the Government military engineers who are performing these duties, as on detached service, and there is no precedent for this condition of affairs in foreign countries, where, although an ample military organization exists, the civil works are placed entirely under the control of a civil corps, specially trained and qualified for the purpose. The bill now in Congress is not prepared in the interests of a class of professional specialists, but to best promote the general welfare and commercial prosperity of the entire country. Its peculiar features and the means by which these ends are proposed to be attained, are admirably stated in Senator Cullom's contribution to the May number of the *Forum*, entitled "Appropriations for Public Works."

The provisions of the bill have been well sifted by discussions in technical papers and societies, and a few modifications made to meet the minor objections which have been made, until it is believed to be in the best possible shape. It provides for a subdivision of the country into ten or eleven topographical basins or departments, over each of which there shall be a permanent chief or department engineer, who will again subdivide into districts with local officers who are to be held individually responsible, and to be subject to promotion based upon relative merit. There will be a chief executive officer and an advisory council, and all plans, projects and estimates shall be forwarded and approved through the authorized channels to Congress. Appropriations shall be made for the completion of the project, payable by instalments as required, and all larger works will stand upon their merits and

importance. For continuous operations, such as dredging and snagging and for lesser works, a general bill will be prepared, and the aggregate amount will be divided pro rata between the departments. H.

CHEMISTRY.

THE EMPLOYMENT OF MAGNESIUM POWDER for photographic purposes by blowing it into the flame of a lamp, seemed positively void of any danger of serious explosion; but recently in employing the bottle containing the powder with two tubes (as described in this JOURNAL, **125**, 262) and a pneumatic bulb, upon releasing the latter from pressure the flame was drawn back into the bottle and produced a violent explosion. This source of danger can, of course, be easily eliminated. C. F. H.

PHOTOGRAPH OF THE HUMAN EYE BY MAGNESIUM FLASH LIGHT.—By means of the magnesium flash light a photograph was taken (*Nature*, **38**, 13), at the suggestion of Du Bois Reymond, of a normal eye, life-size, after a quarter of an hour's rest in a completely darkened room, showing the pupil of the eye fully dilated, as its reaction does not begin until after exposure. Hitherto the effect of complete darkness on the pupil could only be observed by the light of the electric spark, but these photographs permit of measurements. C. F. H.

A DIRECT METHOD FOR DETERMINING THE ABSOLUTE TIME OF INSTANTANEOUS PHOTOGRAPHIC EXPOSURES, and the rate of movement of the shutter, is given, with illustrative examples, by Wallace Goold Levison in a paper read before the New York Academy of Sciences, January 16, 1888, and seems susceptible of refinement that may adapt it to other scientific purposes. It is essentially a tuning-fork method. A beam of sunlight from a heliostat, after falling upon a mirror attached to the prong of a tuning-fork, is condensed to a brilliant point upon a sensitive plate, or, still better, a sensitive film, attached directly to the moving shutter. The vibrating fork causes the spot to describe a sinusoid on the moving shutter, bounded at each end by transverse straight lines, which appears on development. The number and proportionate widths of the complete undulations, with the frequency of the tuning-fork, afford the data for computing the time of exposure and the rate of motion, which latter varies during the motion, when a retractile spring is employed; the motion being accelerated, as the tracing shows, even when the shutter moves vertically upward. A rotating disc with sensitive film can be used instead of the sliding shutter for certain kinds of measurement. Among the applications of the method, the writer suggests the timing of electric discharges, of the magnesium flash, and to astronomical photography. Due credit is given Londe for his method, from which this differs in the direct action of the light upon the moving shutter, without intervention of lenses. C. F. H.

INSOLUBLE GELATINE FILMS AS A SUBSTITUTE FOR GLASS IN EMULSION PHOTOGRAPHY.—Alfred Stieglitz in the *Photographische Mittheilungen*, quoted in the *Photographic Times*, **18**, 141, gives the following account of

the manner of preparing the vergera gelatine films of which so much has lately been written :

As a carrier of the sensitive emulsion the purest gelatine is used, which is hardened with potassium bi-chromate nearly to insolubility ; then boiled again until liquid. Plates are coated with it, and the films are dried in a dust-free apartment. When quite dry these plates are exposed to light, after which the gelatine is found to be hard and insoluble in boiling water.

To remove the yellow tint of the plates, caused by the bi-chromate, they are washed in a moderately strong acid bath. After drying again, they are coated with the sensitive emulsion. When hard and dried in the usual way, the films are stripped from the glass and are then ready for exposure.

The subsequent treatment is the same as that with a glass plate, only after the films have been thoroughly washed, they must be laid for fifteen minutes in alcohol to effect a quick and uniform drying. W.

GEOGRAPHY.

INTERNATIONAL GEOGRAPHICAL CONGRESS IN PARIS.—The Geographical Society of Paris has decided to take advantage of the presence of the many savants who will attend the Universal Exposition in Paris next year, by calling together a Geographical Congress, which will meet next August a year. The sections into which the Congress will be divided are six, as follows :

- (1) Geodesy (Hydrography and Topography).
- (2) Physical Geography.
- (3) Economic and Commercial Geography.
- (4) Historical and Ethnographical Geography.
- (5) Pedagogical Geography.
- (6) Cartography.

The usual arrangements are adopted for the payment of admission dues and the receipt of the published proceedings of the Congress, to which will be added a commemorative medal.

The French Geographical Society, which has taken the initiative in this matter, suggests that each Society represented at the Congress shall produce a catalogue of those investigations, publications, etc., of its own country, which have most contributed to the progress of the science of geography during the last century.

These catalogues published together, each with the names of its authors, will form a most valuable volume of reference for the science.

The circular is signed by the President of the French Society, the President of the Central Commission, and the General Secretary ; the Vice-President of the Central Commission, and the General Secretary of the Society of Commercial Geography. These latter facts are only mentioned here to remark that out of all the signatures but one of them is clearly legible, and two are absolutely illegible. It seems as if all over the world the legibility of handwriting is decreasing as knowledge of the arts and sciences increases. There are few of the smooth and unmistakable handwritings of a century ago.

A Geographical Congress, which was to have met in April, was postponed on account of the death of the Emperor William I. P. F.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE DURING JUNE AND JULY, 1888.

- Alabama. Reports of the Railroad Commissioners for 1886 and 1887.
Presented by the Commissioners.
- Allen, L. F. Rural Architecture. New York, 1856.
Presented by Mr. S. H. Needles.
- American Institute of Mining Engineers. Index Vols. 1 to 15.
Presented by the Institute.
- Anvers. Port de mer. Bruxelles, 1885. Presented by Mr. L. S. Ware.
- Association Amicale des Anciens élèves de l'école centrale des Arts et Manufactures. Annuaire 1832-86, 1832-87. Paris, 1887-88.
Presented by Mr. L. S. Ware.
- Baltimore. Fifty-ninth Annual Report of the Board of Commissioners of Public Schools for 1887. Baltimore, N. D. Presented by the Board.
- Banquet to Commemorate the Framing and Signing of the Constitution of the United States. Philadelphia, 1888.
Presented by the Committee on Arrangements.
- Beedell, E. The British Tariff for 1856-57. London, 1856.
Presented by Mr. S. H. Needles.
- Board of Supervising Inspectors of Steam Vessels. Proceedings of the Thirty-sixth Annual Meeting. Part 1. Presented by the Board.
- Booth, J. C. Phonographic Instructor. Philadelphia, 1850.
Presented by Mr. S. H. Needles.
- Brooklyn Library. Thirtieth Annual Report for 1887.
Presented by the Library.
- Buffalo City Water Works. Nineteenth Annual Report for 1887.
Presented by the Chief Engineer.
- Bureau of Statistics. Quarterly Report. No. 3, 1887-88.
- Statistical Abstract of the United States. Tenth Number. Washington, 1888.
Presented by the Bureau.
- Calhoun. Monument at Charleston, S. C. History. Charleston, 1888.
Presented by the Ladies' Calhoun Monument Association.
- California. Annual Meteorological Review for 1887.
Presented by Sergeant J. A. Barwick.
- Carriage Monthly. Vol. 17, 1881-2.
Presented by Messrs. Ware Brothers, Publishers.
- Census United States. Tenth. Vol. 10, Part 2 and plates.
Presented by Hon. John I. Mitchell.
- Central Pacific Railroad. Argument of Creed Hammond.
Presented by Central Pacific Railroad Company.
- Chevallier, M. A. Dictionnaire des Alterations et Falsifications des Substances. Paris, 1854-55.
Presented by Mr. R. A. Fisher.

- College of Science, Imperial University Japan, Journal. Vol. 2, Part 1.
Presented by the College.
- Commercial Exchange, Philadelphia. Thirty-fourth Annual Report.
Presented by Mr. C. Ross Smith, Secretary.
- Cooper Union. New York City. Twenty-ninth Annual Report, 1888.
Presented by the Cooper Union.
- Coupland, S. Personal Appearances. New York, 1879.
Presented by Mr. L. S. Ware.
- Cox & Co. List of Persons who have been Advertised for in Proceedings in the Court of Chancery.
Presented by Mr. L. S. Ware.
- Department of Agriculture United States. Report for 1887. Botanical Division. Bulletins Nos. 5 and 6. Report of the Statistician. Nos. 51 and 52.
Presented by the Department.
- Engineers' Society of Western Pennsylvania. Papers and Discussions to May, 1888.
Presented by the Society.
- Geological Survey of India. Memoirs. Palæontologia Indica. Ser. 13, Vol. 1, No. 7.
Presented by the Survey.
- Hargreaves, W. Our Wasted Resources. New York, 1879.
Presented by Mr. L. S. Ware.
- Hydrographic Office. United States Pilot Chart of the North Atlantic Ocean, June and July, 1888.
Presented by the Office.
- Institution of Civil Engineers. Minutes of Proceedings. Vol. 92.
Presented by the Institution.
- Jaeger, G. Sanitary Woollen System. London, N. D.
Presented by Mr. L. S. Ware.
- Jousse Commentaire sur l'ordonnance du Commerce. Paris, 1841.
Presented by Mr. S. H. Needles.
- Kansas. Crop and Weather Bulletin. For April and May, 1888.
Presented by the State Board of Agriculture.
- Kansas State Board of Agriculture. Report for the Quarter ending May 31, 1888. Topeka, 1888.
Presented by the Board.
- Kansas. Third Annual Report of the State Board of Health for 1887. Topeka, 1888.
Presented by the Board.
- Laughenhove, R. van. Armements en Europe et en Amérique. Bruxelles, 1888.
Presented by Mr. Eugene H. Cowles.
- Liebig, J., J. C. Poggendorff und F. Wohler. Handwörterbuch der Chemie. Braunschweig, 1842-61. 9 V.
Presented by Mr. R. A. Fisher.
- Literary and Philosophical Society of Manchester. Proceedings. Vols. 25 and 26. Memoirs. Vol. 10. 3 S.
Presented by the Society.
- Locomotive, The. Vol. 8. 1887.
Presented by the Hartford Steam Boiler Inspection and Insurance Co.
- Louisiana Biennial Report of the Board of Health. Baton Rouge, 1888.
Presented by the Board.
- Löwig, Carl. Chemie der organischen Verbindungen. Braunschweig, 1846-7.
Presented by Mr. R. A. Fisher.
- Macfie, R. A. Copyright and Patents for Inventions. Edinburgh, 1879 and 1883.
Presented by the Author.

- Massachusetts. Charitable Mechanics' Association. Report of Sixteenth Exhibition. Boston, 1888. Presented by the Association.
- Massachusetts. First to Third Annual Reports of the Board of Gas Commissioners for 1885-1887. Presented by the Board.
- Massachusetts. Nineteenth Annual Report of the State Board of Health. Boston, 1888. Presented by the Board.
- Massachusetts State Agricultural Experiment Station. Bulletin No. 29. Presented by the Station.
- Mercantile Library Association of New York. Sixty-seventh Annual Report of the Board of Direction for 1887-1888. New York, 1888. Presented by the Association.
- Meteorological Council Royal Society London. Hourly Readings. Part 3. 1885. Quarterly Weather Report. Part 3, 1879. Presented by the Council.
- Meteorological Department. India. Indian Meteorological Memoirs. Vol. 4, part 4. Dallas. Memoir on the Winds and Monsoons of the Arabian Sea and North Indian Ocean. Calcutta, 1887. Report on the Meteorology of India. 1886. Presented by the Meteorological Department.
- Meteorological Observations Recorded at Six Stations in India, December, 1887. Presented by the Meteorological Department.
- Meteorological Office. London Monthly Weather Review. April, 1887. Weekly Weather Report, February 27th to May 7th, 1888, inclusive. Presented by the Office.
- Michigan. Fourteenth Annual Report of the State Board of Health for 1886. Lansing, 1887. Baker, H. B. Causation of Pneumonia. Presented by the Board.
- Milwaukee Annual Report of the Board of Public Works for 1887. Presented by the Board.
- Morley, John. Life of Richard Cobden. London, 1882. Presented by Mr. L. S. Ware.
- Morphy, Paul. Exploits and Triumphs. New York, 1859. Presented by Mr. S. H. Needles.
- National Association of Builders. First and Second Convention. Boston, 1887-1888. Presented by the Association.
- National Association of Master Plumbers of the United States. Proceedings of First to Fifth Conventions. New York, etc. 1883 to 1887. Presented by the Association.
- New Brunswick, N. J. Fifteenth Annual Report of the Water Commissioners for 1887. Presented by the Commissioners.
- New Haven. Annual Report of the Board of Health for 1887. Presented by the Board.
- New Jersey Agricultural Experiment Station. Bulletins Nos. 44 and 45. Presented by Mr. L. S. Ware.
- New Jersey Geological Survey. State Map. Presented by Prof. G. H. Cook, State Geologist.
- New York City. Report of the Fire Department for 1880. New York, 1881. Presented by Mr. S. H. Needles.

- Ordnance. Annual Report of the Chief for 1887. Washington, 1888.
Presented by the Chief of Ordnance.
- Oregon. Resources of the State. Salem, 1888.
Presented by Mr. B. S. Payne.
- Otto, Fr. Jul. Lehrbuch der Chemie. Braunschweig, 1848=49.
Presented by Mr. R. A. Fisher.
- Painter's Manual. New York. Presented by Mr. S. H. Needles.
- Patent Office, United States. Specifications and Drawings. January, 1887.
Presented by the Office.
- Peabody Institute of Baltimore. Twenty-first Annual Report. 1888.
Presented by the Institute.
- Pennsylvania Report of the Board of Commissioners of Public Charities for 1887.
Presented by the Commissioners.
- Pennsylvania State College Agricultural Experiment Station. Bulletin No. 3.
Presented by the Station.
- Philadelphia Photographer. Vols. 1 to 3. 1864 to 1866.
Presented by Mr. W. B. Le Nau.
- Philosophical Society of Washington. Bulletin Vol. 10.
Presented by the Society.
- Pratt Institute. Announcement, etc. 1888. Presented by the Institute.
- Record Almanac. Philadelphia, 1881. Presented by Mr. S. H. Needles.
- Roberts, Alex. Companion to the Revised Version of the New Testament.
Presented by Mr. L. S. Ware.
- Ross, E. W. & Co. Ensilage and Silos. Presented by Mr. L. S. Ware.
- Royal Society of New South Wales. Vol. 21. 1887.
Presented by the Society.
- Salt Lake City. A Sketch of Utah's Wonderful Resources.
Presented by Mr. L. S. Ware.
- Saward, F. E. Coal Trade. New York, 1878.
Presented by Mr. S. H. Needles.
- Signal Office. Annual Report of the Chief Signal Officer for 1887. Part 1.
Daily International Chart. April and May, 1887. Summary and Review
of International Meteorological Observations for April and May, 1887.
Presented by the Office.
- Signal Service, U. S. A. Contributions to the Natural History of Alaska, by
L. M. Turner. Washington, 1886. Presented by the Signal Service.
- Society of Engineers, London. Transactions for 1887.
Presented by the Society.
- Somerville, Mass. Tenth Annual Report of the Board of Health for 1887.
Presented by the Board.
- State School of Mines, Colorado. Annual Report for 1885-6-7.
Presented by the President.
- Stevens Institute of Technology. Annual Catalogue for 1888-89.
Presented by the Institute.
- Tatnall, E. Catalogue of the Phænogamous and Filicoid Plants of New
Castle County, Del. Wilmington, 1860.
Presented by Wilmington Institute Library.

Teale, T. P. Dangers to Health. London, 1883.

Presented by Mr. Robt. W. Edison.

Texcoco—Huehuetoca Canal. Philadelphia, 1880.

Presented by Mr. L. S. Ware.

United States Geological Survey. Seventeen Atlas Sheets.

Presented by the Survey.

University of Wisconsin. Agricultural Experiment Station. Bulletins Nos. 14 to 16. 1888.

Presented by the Station.

Valin, R. J. Commentaire sur l'ordonnance de la Marine. Paris, 1841.

Two vols.

Presented by Mr. S. H. Needles.

Verities in Verses. London, N.D.

Presented by Mr. R. A. Macfie.

Waltham, Mass. Annual Report of the Board of Health for 1886 and 1887.

Presented by the Board.

Welsbach System of Incandescent Gas Lighting, Description, etc.

Presented by the Welsbach Company.

White, G. Political Economy. Easton, Mass., 1888.

Presented by the Author.

Women's Medical College of Pennsylvania. Thirty-ninth Annual Announcement.

Presented by the College.

Franklin Institute.

[Proceedings of the Stated Meeting, held Wednesday, June 20, 1888.]

HALL OF THE INSTITUTE, PHILADELPHIA, June 20, 1888.

Mr. JOS. M. WILSON, President, in the Chair.

Present, eighty-seven members and twenty-four visitors.

Additions to membership since previous report, six.

The Actuary reported the death of Mr. WILLIAM HELME, a member of the Board of Managers, and the appointment of a committee to prepare a memorial of the deceased.

Mr. WASHINGTON JONES announced the death of WM. PETTIT, one of the oldest members of the INSTITUTE, and moved the appointment of a committee to prepare a memorial, which was carried.

Mr. THEO. C. SEARCH was thereupon elected to fill the vacancy in the Board, *vice* Mr. HELME, deceased.

Mr. C. J. HEXAMER was elected to membership in the Committee on Science and the Arts, to fill the unexpired term of Mr. J. M. EMANUEL, resigned.

Mr. GEO. F. SIMONDS read a paper describing a Universal Metal Rolling Machine of his invention. The paper was illustrated by specimens of the work of the machine, and by a model machine rolling lead in various forms. The paper appears in the JOURNAL for July.

Adjourned.

WM. H. WAHL, *Secretary*.

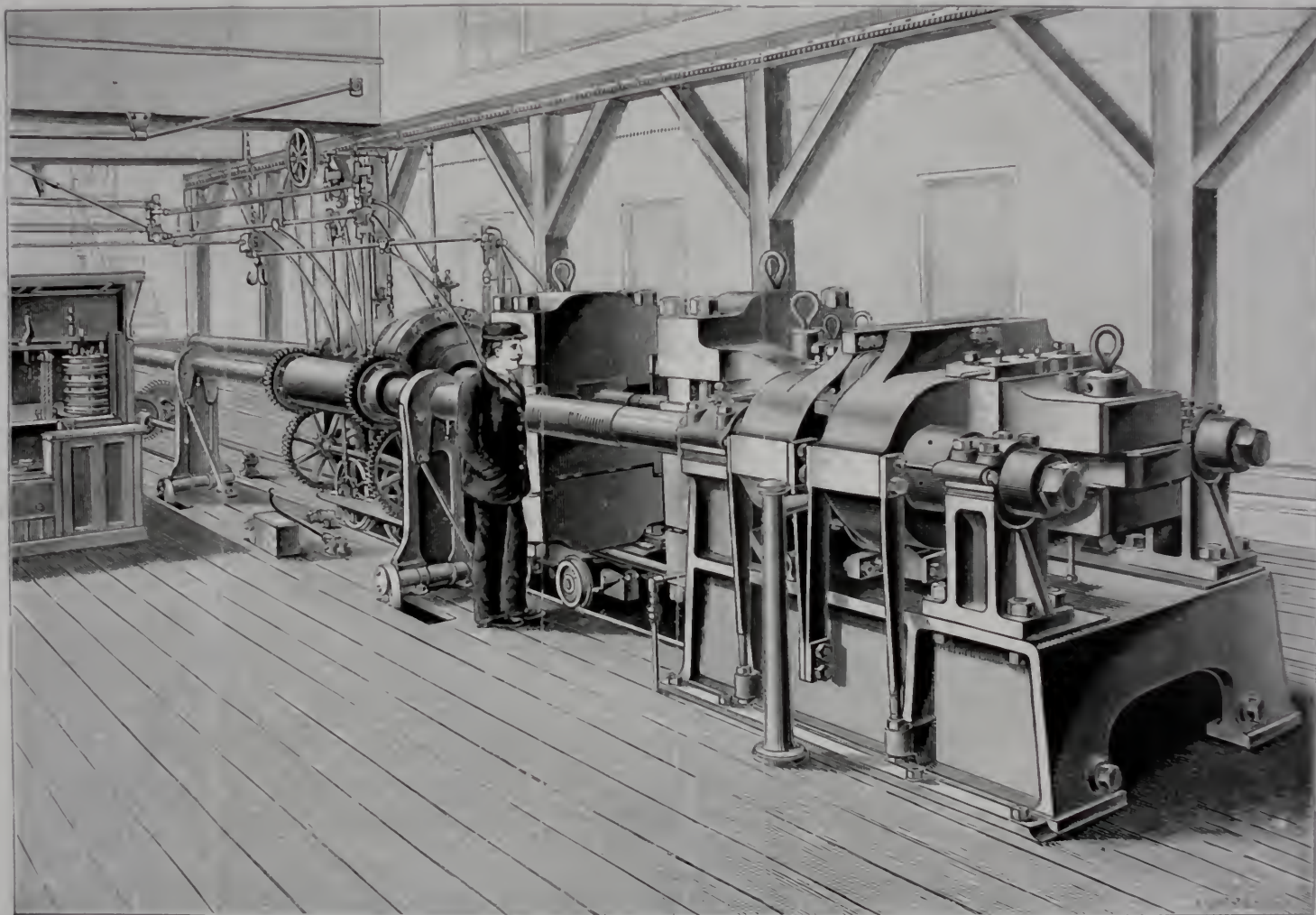


FIG. 12.—The Emery Testing Machine at the United States Arsenal, Watertown, Mass. (General View.)

Jour. Frank. Inst., Vi.)

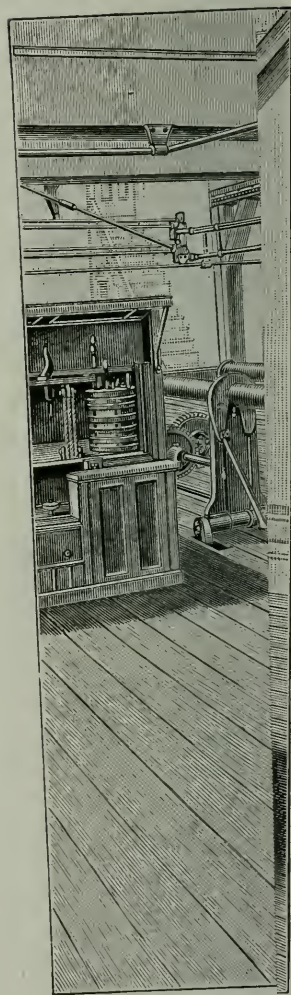


FIG. 1

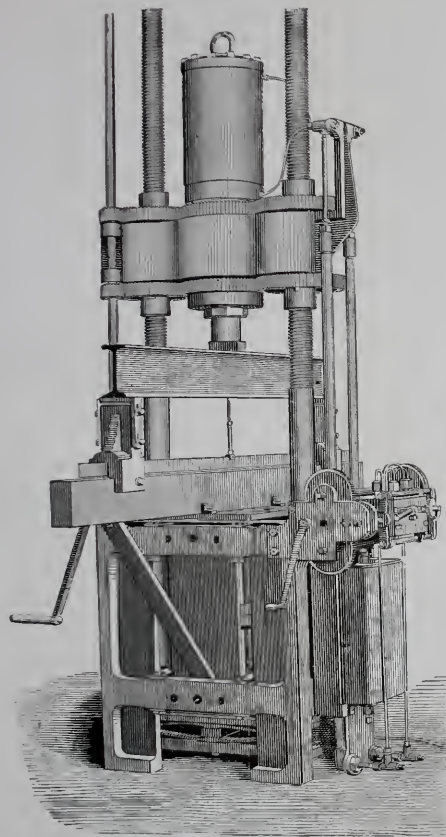


FIG. 13. Elevation of the Machine.

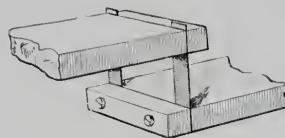


FIG. 15. Clamping Suspension Fulcrums.

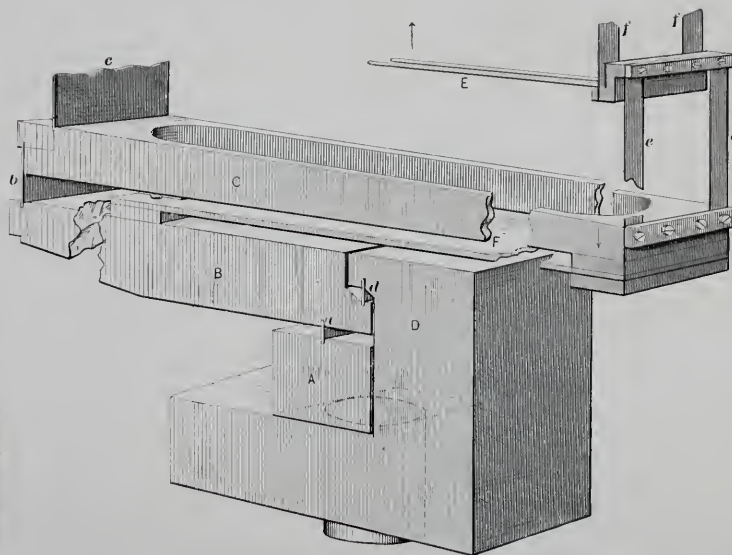


FIG. 14. Levers and Plate Fulcrums.

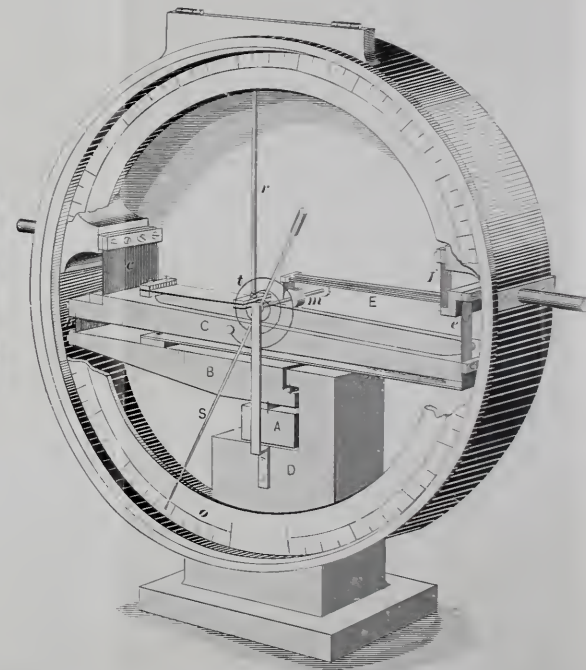
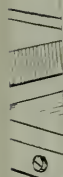


FIG. 16. Hydraulic Gauge.

EME



ig Su



rs and

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI. SEPTEMBER, 1888.

No. 3.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

WEIGHING MACHINES.

BY WM. KENT, M.E.

[*A lecture delivered before the FRANKLIN INSTITUTE, February 10, 1888.*]

Mr. KENT was introduced by the Secretary of the INSTITUTE and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

I had the pleasure of hearing the lecture last Monday evening in this hall, and the lecturer said that it was customary to carry the subjects of lectures back to the book of Genesis and to Homer. My subject, I think, may be carried back to a still greater antiquity, for among the earliest questions asked by man of his fellow-man must have been "How much does it weigh?" And the answer would have been given after reference to the first weighing machine, which is man's

own hand, or his muscular strength. The first example of barter and sale may have included an offer like this from the seller: "For that piece of silver I will give you as much grain as you can lift from the ground, or for that smaller piece I will give as much as you can raise shoulder high." No doubt the weighing was done by the muscles of man before any more accurate machine was invented for the purpose.

A weighing machine is any machine or contrivance used to ascertain the heaviness of a body.

Scientifically speaking, *weight* is the result of the attraction of gravitation upon a body, and as the force of gravity is not the same at different parts of the earth's surface, so the weight of any piece or body, if by weight we mean the effect of gravity upon it, differs according to the place at which it is weighed. Thus the writers on natural philosophy tell us that a mass of iron which weighs 1,000 pounds at the Equator would weigh 1,005 pounds at the Pole; 500 pounds at a point 2,000 miles below the surface or 1,650 miles above it; 2,600 pounds on the surface of Jupiter, and 28,000 pounds on the surface of the sun.

But as ordinarily used, weight does not mean the absolute heaviness of a body or the effect of gravity upon it, but the relative heaviness; that is, its heaviness as compared with that of a certain piece of metal which is taken as a standard, and weighed at the same place and under the same conditions.

The accepted standard in English speaking countries is the pound avoirdupois, which is the weight of a certain piece of metal kept in the custody of the warden of the standards in London. The standard for France and for all countries which have adopted the French system of weights and measures is the kilogram, the weight of a certain piece of metal kept in a government office in Paris.

A weighing machine then is not, generally speaking, used to determine the force of gravity upon a body, but to determine what is its heaviness as compared with that of certain pieces of metal which are assumed to be standards.

For the comparison of standard weights with each other,

for governmental and scientific purposes, instruments of the utmost possible refinement are required, so as to make the error of ascertainment of their relative weights as small as possible. For commercial purposes such refinement is not attempted, but it is desirable that the error of weighing be so small that it can create no dissatisfaction in the mind of either buyer or seller, or user of the weights for any purpose. Thus in weighing tea or sugar in a grocery store, an error in weighing would be allowable if it was not large enough to cheat either buyer or seller by the amount of one cent in the calculation of the total price of the article weighed. In a drug store, the prescription balance should be so accurate that the largest possible error that could be made in weighing the strongest poison known to the Pharmacopœia could not produce the effect of an overdose and endanger the life of a patient. In chemical analysis, the largest allowable error must be less than the limit of accuracy of the process used by the chemist, or say $\frac{1}{1000}$ of one per cent. So the refinement or accuracy necessary in a weighing machine depends chiefly upon the purpose for which the weighing is done.

The mechanical principles upon which weighing machines are based are quite various, but in general they all have one idea in common, that of opposing to the force of gravitation, which acts upon the body to be weighed, some resistance the amount of which can be determined and expressed in units of the accepted standard. I will now enumerate the several mechanical principles which have been adopted or proposed for weighing machines, and show some examples of their application.

(1) *The elasticity of metals or other substances.*

Probably the simplest illustration of this principle is seen in this cheap weighing machine (*Fig. 1*), consisting of a flexible steel strip *A*, rigidly fastened at one end to a firm pedestal *B*, and carrying at its outer end a pan *C*. A one-pound weight placed in the pan *C* will bring the pointer down to the mark 1 on the graduated standard, two pounds brings it down to the mark 2, and so on. By finely graduating the index plate and by reading carefully the

position of the pointer upon it after it ceases vibrating, a fairly accurate weighing machine for a limited range of purposes is obtained.

Weighing on this crude machine is done by the method known as "weighing by substitution," which consists in substituting, for the substance on the scale pan whose weight is to be determined, standard weights sufficient to produce exactly the same effect upon the scale. The sum of the standard weights so used is the weight of the substance. For example, suppose we put on the scale pan of this machine a piece of metal of unknown weight, it depresses the pointer to a spot on the graduated plate, which spot we mark with great exactness. We now carefully remove the piece of metal and substitute standard weights sufficient to

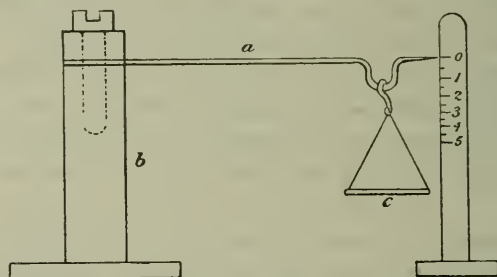


FIG. 1.

bring the pointer to exactly the same position. If it requires just one pound, one ounce and one-eighth of an ounce to bring the pointer to the marked spot, then that is the weight of the piece of metal. This method of substitution is employed in the very finest weighing for scientific purposes, because it enables us to avoid many of the errors common to the ordinary methods of balancing a weight on one side of a scale beam against a weight on the other.

Another form of machine, using the flexibility of this same metal strip, might be made by fastening or supporting the strip at each end on a separate pedestal, and noting the deflection of the middle point. A railroad bridge might thus be used as a weighing machine to weigh the trains of cars that cross it, the heavier the train, the greater of course being the deflection.

The most common illustration of the use of the principle of the elasticity of metals is seen in the ordinary spring balance, which consists simply of a spirally wound wire, which is held at one end and the weight to be weighed suspended from a hook at the other. These wire coils may be used either in compression, like the coiled spring of a street car, or in extension, like the ordinary spring balance. (Specimen shown by the lecturer.) The common form of balance, with a pointer rotating on a dial, is just the same, with the addition of a small rack and pinion to give the rotary motion.

Instead of the elasticity of metal, we may use that of other substances, such as cork, or India-rubber, or we may use the elasticity of air. Suppose a cabinet organ bellows, or a blacksmiths' bellows, perfectly free from leaks, and well inflated with air. Place a pound weight on the upper plate of the bellows, and it will be depressed slightly. Two pounds will depress it twice as much, or nearly so. Thus an index scale of depressions corresponding to certain weights might be constructed, and the bellows thus become a weighing machine. The common gas-holder of the gas works may be used as a weighing machine. It consists of an inner tank inverted in an outside tank, which is filled with water. Gas is introduced into the inner tank, raising it to a certain height. Weights are now placed on the top of the inner tank, depressing it in proportion to the amount of weight. The amount of the depression, recording the pressure to which the contained gas is subjected, is also a record of the weight applied, and thus the gas-holder becomes a weighing machine.

(2) *The buoyancy of liquids.*

I have one illustration of this principle here, in the common hydrometer, used for determining the density of liquids, *Fig. 2*. It may also be used to determine the weight of small bodies. I have it here balanced in strong brine, and a little pan on top of the stem, in which I place this ten-grain weight. It depresses the stem a considerable distance, so that within a range of from one-tenth grain to twenty or thirty grains this hydrometer makes a fair weighing machine.

On the same principle a boat or any vessel floating in water may be used as a weighing machine. When the vessel is unloaded, the water line is at a certain mark. As the vessel is loaded, it sinks deeper and deeper in the water, and successive marks showing the amount of water the vessel is drawing, also measure the weight of the cargo placed on board.

(3) *The chain balance.*

What is called the chain balance is described in the books, but I am not aware that it is ever used in practice.

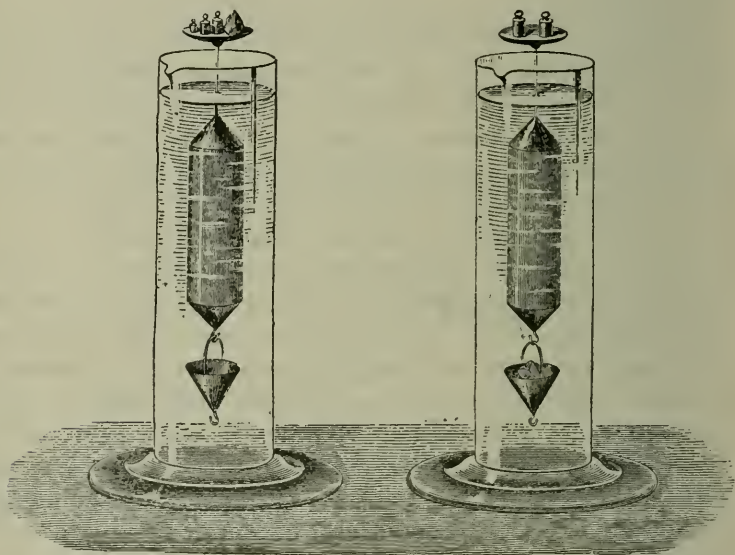


FIG. 2.

I have here a rough model of one, which is chiefly interesting to show how a crude weighing machine might be made if no better one was at hand. It consists simply of two upright posts (*c d*, *Fig. 3*), between which is loosely stretched a cord or chain, *a b*. To two points in this chain are attached the scale pans, *e f*. When the scale pans are unloaded, the chain will take a definite position, depending upon the position of the points of attachment of the scale pans. If one pan is loaded, that pan will take a lower position, while the other one will rise, the angles between the ends of the chain and the posts changing accordingly. If

an equal load be placed in the other pan, the chain will return to its original position.

(4) *The pendulum or bent-lever balance.*

This is a balance which has had rather limited application hitherto, the most commonly-known form being a cheap and not very accurate letter balance, for weighing a few ounces.

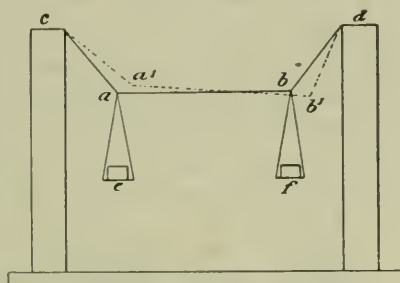


FIG. 3.

I have here a rough model, *Fig. 4*, illustrating the principle, and also a rather complicated modification, a housekeeper's cheap scale, weighing up to ten pounds. It consists, in its simplest form, as the model shows, of a bent arm *a*, pivoted near one end to an upright support, and carrying at the end of the vertical portion a weight *c*, and at the end of the

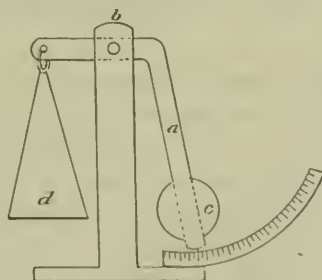


FIG. 4.

horizontal portion the scale pan *d*, suspended from a pivot. It is evident that as weights are placed in the scale pan, the weight *c* will be caused to move outwards from the supporting pillar, until the leverage of the arm and weight on one side of the pillar counterbalances the effect of the weight in the scale pan. The balance may be standardized by

marking on the graduated index the position at which the arm comes to rest under the application of successive weights.

(5) *The hydrostatic balance.*

The most elementary form of this balance is shown in the sketch on the blackboard (*Fig 5*). It is based on the principle of the hydrostatic press, or common hydraulic jack. There are two communicating cylinders, one very much larger than the other, each fitted with a piston. Leakage and friction being left out of the account, a weight placed on the piston of the smaller cylinder will balance a weight on the larger cylinder, which is as many times greater as the area of the larger cylinder is greater than

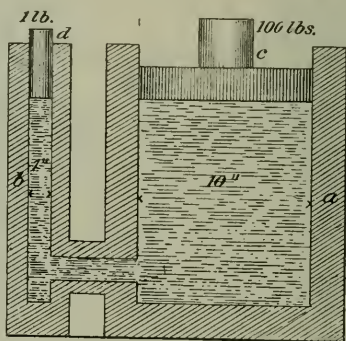


FIG. 5.

that of the smaller. By substituting for the pistons flexible diaphragms, the objections of leakage and piston friction are avoided, and upon this principle are constructed the hydraulic-weighing apparatus used in the Emery testing machine, which will be referred to later.

(6) *The even balance.*

The weighing machines based on the principles already referred to are of quite restricted application. We now come to the simplest, most ancient, and most universally used form of weighing machine, the even balance. I have here the rudely constructed parts of a model, consisting of two pieces of board, three feet long and five inches wide, a supporting pillar and two upright pan supports, and two pans with strings for suspending them, also a number of

different kinds of pivots, with which I will construct several rough models illustrating the even balance in many of the forms it assumes in use. No doubt the earliest form of the even balance was the "see-saw," used by children in their play, a plank placed across a log, and a child on each end balancing one another. As an accurate weighing machine, however, the "see-saw" is not a success, on account of the friction and variableness of position of the middle bearing. The first improvement on the see-saw was probably made by turning the plank up edgewise to give it greater resistance to bending, and boring a hole in the middle of it, and inserting a pin in the hole, supporting the pin also on a bifurcated support. This is shown in the form now presented in the model (*Fig. 6*). By suspending the scale pans

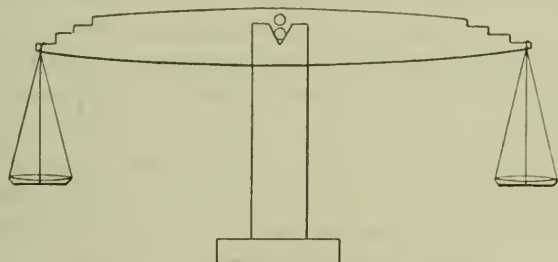


FIG. 6.

from the ends of the board by means of strings, we have a fairly good suspended-pan even-balance weighing machine. You observe that a pound weight in one pan balances a pound weight in the other.

Removing the pans, and considering the action of the beam itself, we may learn some important facts concerning the construction of the even balance. First we notice that the pin has a certain amount of friction in its bearings, which brings the beam to rest after two or three oscillations, and prevents its being set in motion except by the addition of quite an appreciable weight on one side or the other. This is very objectionable in a weighing machine, and teaches us that a perfect balance should have a frictionless pivot. Let us make the pivot of polished steel, of small diameter, so as greatly to reduce the friction, and we dis-

cover another peculiar feature of the even balance. If the pin is placed in the uppermost of the three holes the beam oscillates rapidly. When brought to rest a half-ounce weight placed on the end of the beam moves the beam out of its normal or horizontal position to a slight degree only. Place the pin in the lowest of the three holes, and the beam will not remain in the horizontal position at all, but will fall to one side or the other, showing a tendency to turn upside down, so as to bring the supporting pin in the upper edge of the beam as before. This is the condition of unstable equilibrium, or top-heaviness, while in the first test, in which the supporting pin is in the uppermost hole, the condition is one of stable equilibrium. By such tests we learn that there is a position of the supporting pivot which will give the best results, namely, great sensitiveness, without top-heaviness, and this position is almost at the exact centre of gravity of the beam, but a trifle above it. If the pivot be placed exactly at the centre of gravity, the beam will be in neither stable nor unstable equilibrium, but in what is called indifferent equilibrium, that is the beam will have neither a tendency to return to the horizontal position, nor to fall towards one side or the other, but will remain indifferently in any position it may happen to be placed. The centre of gravity must be just a little below the centre of support, so that as the centre of gravity always tends to take a position in a vertical line below the point of support, the beam will always tend to return to the horizontal. Placing the pin in the middle one of the three holes we notice that the beam oscillates very slowly, but always comes to rest in a horizontal position. A half-ounce weight placed on one end of the beam now deflects the beam to a much greater extent than when the pin was in the upper hole.

The round pin, however, is still objectionable as a pivot on account of its friction, which cannot be got rid of, as well as for other reasons of which time will not permit me to speak. Suffice it to say that the round pivot has been replaced by the knife edge in nearly all balances which have been used during the past 2,000 years at least. The balances used in ancient Rome, according to pictures which have come

down to us, show the use of the knife edge, and I have no doubt the balances shown in the sculptured pictures of the Egyptian pyramids also had knife edges. (The lecturer here showed on the screen a picture of an Egyptian balance, and also the picture showing the ceremony of weighing the Great Mogul of Tartary.)

Instead of suspending the scale pans by means of strings tied to the ends of the beam, as I have them in the model, it is usual to have knife edges firmly set into the ends of the beams, to which the pan supports are attached by means of swinging links. By means of the three strings which are attached to each end of the model beam, each passing through a hole and secured by a knot resting on one of the little steps at the end of the beam, we can show that it is a matter of great importance that the points from which the pans are suspended should have a certain position in reference to a horizontal line passing through the centre of gravity of the beam. With the pivot supporting the beam in its proper position, just a trifle above the centre of gravity of the beam, if we attach the pans to the strings attached to the outer and lower step, and put weights in them, the balance ceases to be sensitive. It oscillates rapidly, and is in too stable equilibrium. If we tie the pan supports to the innermost strings, which are suspended by the knot on the uppermost step, the balance again becomes top-heavy, or in unstable equilibrium. If we attach the pan supports to the middle string, supported by the knot on the middle step, the balance oscillates slowly, no matter whether lightly or heavily loaded, it is quite sensitive to small additions of weight to either pan, and it always returns to the horizontal position. Hence we learn that the end pivots of a suspended-pan balance of this general class, that is with round or knife-edge pivots, should always be on a horizontal line with the middle pivot, that is the edges of the three knife edges should be in the same plane.

I have here a very fine scale beam, with three knife edges, made by Mr. Troemner, of Philadelphia, from which may be learned the accuracy of workmanship necessary to

make a good knife-edge balance. The end pivots must be exactly equidistant from the centre pivot, the edges of the three pivots must lie in the same plane, the edges of each pivot must be exactly at right angles to the beam, both horizontally and vertically, which condition also assumes another essential requirement, that the edges must be parallel with each other. Those of my audience who are expert machinists will recognize the fact that to produce absolute exactness in all these conditions is a practical impossibility, and that to produce sufficient exactness to meet the requirements of a fine weighing machine is one of the most difficult tasks that can be performed by a mechanic. I have a number of knife-edge balances here, kindly loaned for this lecture by Messrs. Riehlé Brothers, of this city, which show various modifications of construction.

(7) *The lever or steelyard balance.*

The even balance has one serious objection as a weighing machine for heavy weights, viz: the necessity of placing weights in one pan of the balance equal to the weight of the substance which is being weighed in the other. For weights up to ten or twenty pounds, this is no great inconvenience, but when we wish to weigh hundreds or thousands of pounds it becomes intolerable. This led to the adoption in very early times of the lever balance or, as it is sometimes called, the Roman steelyard. The picture shown on the screen of an ancient Roman balance bears very close resemblance to the steelyards used at the present day. The principle upon which this balance is based is that of the *léver*, namely, that a heavy weight suspended from the end of the short arm of the lever may be balanced by a smaller weight suspended from the end of the long arm, the weights being inversely proportional to the lengths of the arms, or the product of the heavier weight multiplied by the length of the short arm being equal to the product of the lighter weight multiplied by the length of the long arm. This may be illustrated by the model. If we place the supporting pivot in one of the holes near one end of the beam, so that the distance of the *pin* from one pan support is three times its distance from the other pan support, and add enough

weight in the pan on the short arm to balance the beam, then place three pounds in the pan on the short arm and it will be exactly balanced by one pound placed in the other pan (*Fig. 7*).

In practice the steelyard balance does not generally have a pan support, or weight holder attached to each end of the

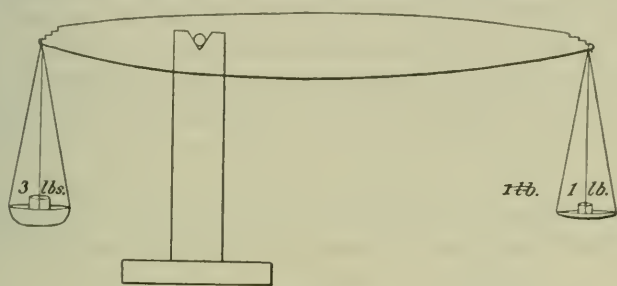


FIG. 7.

balance, but only to the short end, while on the long arm there is a movable weight, which may be placed at any position required to balance the weight suspended from the short arm. This is shown in the ancient Roman picture. Marks and nicks are placed upon the beam to indicate the positions at which the movable weight should be placed to

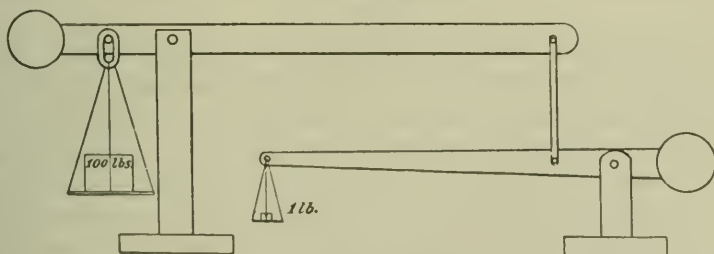


FIG. 8.

counterbalance certain definite weights suspended from the short arm.

(8) *The compound lever balance.*

This is merely an extension of the principle of the steelyard, by using two or more steelyards linked together as shown in the sketch (*Fig. 8*). If a weight of 100 pounds is suspended from the short arm of a beam, whose arms are to each other as 10 to 1, a force of ten pounds applied at the

end of the long arm will balance it, but this force may be applied by means of a second lever. If this second lever also has a ratio of length of arms of 10 to 1, one pound applied at the end of the long arm of the second lever will balance 100 pounds at the short end of the first lever, the weights of the levers themselves of course being first counterbalanced so as to remain in balance when unloaded.

(9) *Combinations of two or more of the eight principles.*

A great variety of combinations of the various forms of balance already described are in actual use as weighing machines, but time will not permit of their being considered in detail.

The even balances and lever balances heretofore discussed all have the scale pans suspended from the beams, but for

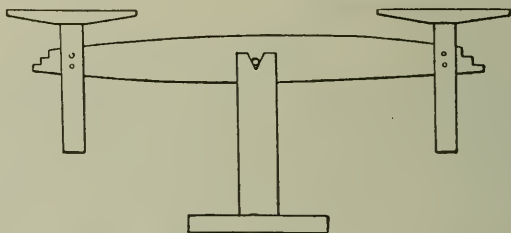


FIG. 9.

many purposes suspended scale pans are inconvenient, and upright pans supported above the beam are desired.

Returning to our model, we rigidly attach two pans to the beam, by pinning each pan support to the ends of the beam by two pins (*Fig. 9*). We now place a pound weight on the centre of each pan, and the scale balances correctly. But if we move one of the weights a fraction of an inch outwards from the centre of the beam, the beam will be depressed on that side, an effect exactly the same as would follow from moving outwards the sliding weight on the lever balance. This method of attaching the pans is therefore incorrect, and the balance as thus constructed is a failure. In order to make a successful upright-pan balance, it is necessary to allow the pan supports freely to move on the end pivots of the beam, instead of rigidly attaching them to it, and at the same time to insure that they retain a vertical position, no

matter what deviation from the horizontal the beam may take in its oscillation. This is accomplished by adding to the structure a parallel motion, which we do on the model by placing a second beam, a duplicate of the first, underneath the latter, and pinning each pan support near its lower end to this lower beam, by one pin, and near its upper end by one pin to the upper beam, so that while both beams oscillate together the pan supports, slightly rotating on the pins, preserve a parallel and vertical position (*Fig. 10*). If we now place a pound weight on each pan, the scale will balance as before, but if we move either weight to any side or corner of the pan, it will still balance, eccentricity of loading having no effect to disturb the equilibrium. This is the principle of all upright-pan pivot balances. In ordinary knife-edge

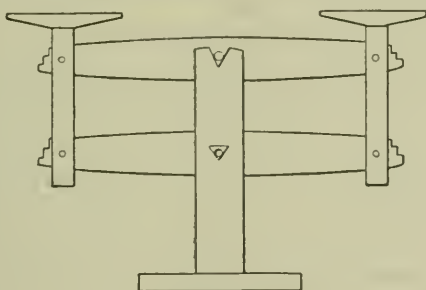


FIG. 10.

upright-pan scales, such as the one shown on the table, an ordinary grocer's counter scale, the lower beam is hidden in the casting, close to the table, and here it takes the form of a slender rod, pivoted to the central support and to the pan supports by round pin pivots instead of knife edges. The lower beam is sometimes made in two parts, being cut in half in the middle of its length, each half being separately pivoted to the central support. Each half of the lower beam is then called a radius arm.

The same principle is adopted in upright-pan lever or steelyard balances, such as the small Fairbanks' letter scale here shown, only one-half of the lower beam, or one radius arm being needed in this case to keep the pan support vertical, since there is only one pan and one pan support used in this style of balance.

The modern platform scale, which was invented by Thaddeus Fairbanks more than fifty years ago, is a compound lever balance. Imagine four of these small steelyard scales placed at the four corners of a rectangle, their graduated beams all pointing towards the centre, where they are separately connected to four strings tied one to the end of each beam, the four strings tied together into one a short distance below, and carrying a pan for holding weights. A flat plate or board may now be placed on top of the four scales, its four corners resting one on each scale. We now have a crude representation of the main principle of the platform scale. I have here an actual platform scale, of the same general style as Fairbanks', which is made by Riehlé Brothers, of this city. (The lecturer here described the construction of this scale.)

I have already stated that the round pivot for balance scales is so objectionable on account of its friction that it is almost never used in weighing machines which have any pretension to accuracy, and that for 2,000 years, or more, knife-edge pivots have been in use as the best kind of pivot. In this age of invention, when the things that were good enough for our ancestors are not good enough for us, many attempts have been made to find a better pivot than the knife edge, which shall be free from the objections of the friction which is a necessary defect of its action, even when new and finely finished, but especially of its want of permanency, the knife edge being extremely susceptible to injury from crushing, bruising, the action of the atmosphere, dust, etc. In quite recent times these attempts have met with success, and I now have the pleasure of exhibiting some forms of pivot balance in which knife edges are dispensed with.

The flexure pivot balance.—The first of these is the flexure pivot balance, which I will show by attaching a flexure pivot to the wooden model which has already done us such good service (*Fig. 11*). I have here two short pieces of flat spring steel, which are clamped tightly in two small vises or clamping pieces, so that about half an inch of each strip is left exposed between the faces of the

clamps. Attaching one clamp to our model beam, and one to the pedestal, you notice that the beam oscillates freely, by bending slightly the thin steel strips. I have copies of two English patents, one by J. M. Taurines, of Paris, dated December 18, 1861, and one by Frederick D. Artingstall, of Manchester, dated September 8, 1862, which show and describe balances made on flexure pivots very similar to the one here shown, but I am not aware whether Mr. Taurines or Mr. Artingstall ever made weighing machines for the market on this principle, although it would appear that practical weighing machines might be made under their patents, provided that sufficient mechanical skill were used in the details of construction. In 1872 and also in

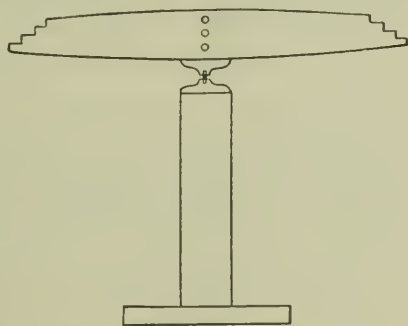


FIG. 11.

1883 and 1884, Mr. A. H. Emery obtained patents on weighing machines, in which are combined the principles of the flexure-pivoted beam and the hydrostatic balance with flexible metallic diaphragms, which has already been referred to. In 1879 Mr. Emery completed, at a cost of over \$100,000, his famous testing machine on this combination of principles, which has since that date been in the service of the United States Government, at the Arsenal at Watertown, Mass. It is used for testing the strength of metals and other materials of construction, and has a capacity of 800,000 pounds for strains of either tension or compression, and can test specimens of any length up to thirty feet. A very complete description of this remarkable testing machine was published in a pamphlet entitled, "A New
WHOLE NO. VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.)

System of Weighing Machinery," issued in 1884, by the Yale & Towne Manufacturing Company, of Stamford, Conn. From this pamphlet I have taken a few cuts which I will show on the screen.

The Yale & Towne Manufacturing Company, made a number of testing machines under the Emery patents, of capacities ranging from fifty to 150 tons, one of which is also shown on the screen. They also made a few platform scales of large capacity on the same principle, but I believe these have not yet been brought into regular use, nor have any small weighing scales for ordinary uses yet been put on the market on the flexure principle. Messrs. Wm. Sellers & Co., of this city, have recently secured the right to build testing machines under Mr. Emery's patents, but I am not aware how far they have progressed in their manufacture. *Figs. 12 to 16*, illustrate various portions of this machine.

The torsion balance.—We will now return to our model beam again, and attach another kind of a pivot, which consists of a flat band or wire tightly stretched around an iron frame or truss, so that two straight portions of the endless band are free to be twisted (*Fig. 17*). The beam is firmly clamped to one of these straight portions, at right angles to its length, and supported by it (*Fig. 18*). You observe that as the beam is oscillated, the wire or band twists, hence the name, the Torsion Balance. Professors Gauss and Weber, of the University of Gottingen experimented upon balances with a twisting wire for a pivot a good many years ago, but their experiments and those of some others were so unsuccessful, that the Encyclopædia Britannica states that if used for large weights the beam would have to be supported by knife edges and bearings, and that, therefore, the torsion balance has no *raison d'être*. One of the causes of the failure of the earlier experiments was the want of a correct way of stretching the wire. This was remedied in 1882 by the late Prof. Frederick Roeder, of Cincinnati. A greater trouble, however, and one which seemed to be fatal to the hopes of the torsion balance, was the fact that as soon as the torsion band or wire was given sufficient size to make it strong

enough to carry a desired weight, the elasticity of the wire became so great as to destroy the sensitiveness of the balance. Dr. Alfred Springer, Prof. Roeder's associate, discovered that the objectionable effect of the elasticity of the wire could be entirely overcome by making the beam "top-

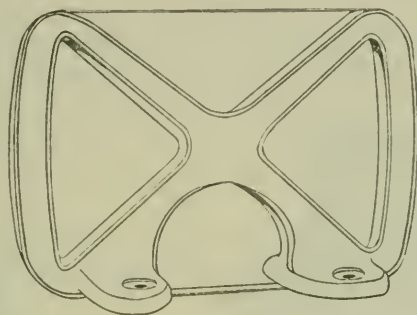


FIG. 17.

heavy," that is by raising its centre of gravity above the point of support or axis of oscillation. He thus used the force of gravity to overcome the resistance of the wire to being twisted. On this model beam we can raise or lower the centre of gravity by raising or lowering the poise

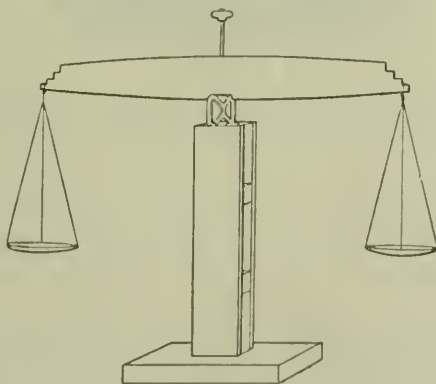


FIG. 18.

weight which is carried on a screw bolt above the centre of the beam. On removing the poise weight we notice that the beam oscillates quite rapidly, say twice every second, while the weight of a penny placed on one end of the beam has little appreciable effect in depressing that end. If we

now raise the centre of gravity of the beam, by placing the poise ball on the screw, the oscillations decrease to ten or less per minute, and a penny placed on one end deflects the beam through a large angle. By raising the poise a little, we decrease the rate of oscillation still more, and the beam becomes exceedingly sensitive, while still remaining in stable equilibrium, that is, the beam always comes to rest in the horizontal position, but if we raise the poise too far the gravity of the poise overbalances the resistance of the elastic wire, the balance is top-heavy, or in unstable equilibrium, and the beam tips to one side or the other, but never remains horizontal.

This system has been thoroughly tested since 1882, and balances have been made on the principle so delicate that

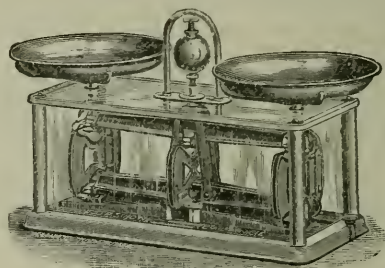


FIG. 19.

they would indicate a weight as small as $\frac{1}{25,000}$ th part of a grain, and others so strong that they have carried a weight of 500 pounds on each pan, and yet when loaded with that weight would indicate an addition to either pan of two grains. Platform scales of 1,000 pounds capacity, and automatic grain scales, which are filled, weighed and dumped automatically, at the rate of 200 bushels per hour, have also been made on this principle. The torsion balance in its improved form is now being placed on the market by The Springer Torsion Balance Company, which has recently built a new factory especially for its manufacture in Jersey City. I have several samples of various styles on the table, which may be examined at the close of the lecture. The druggist's counter scale (*Fig. 19*) has a working capacity of twenty pounds on each pan and will indicate an addition of

half a grain. This scale has now been on the market nearly two years. The small letter scale, eight ounces capacity (*Fig. 20*), is only a few weeks old, and the prescription scale (*Fig. 21*), which is the most recent improvement on one which was introduced two years ago, may be called an advance copy of one which will be put on the market next month, this particular scale having been finished only to-day in order to be shown here to-night.

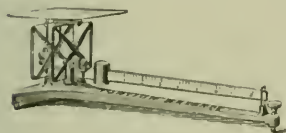


FIG. 20.

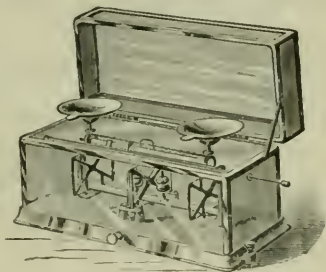


FIG. 21.

It contains a new style of sliding weight or rider beam for small weights (*Fig. 22*), a beam engraved on its upper edge for weights from one-eighth grain up to eight grains, and on its lower edge from one-half centigram to five decigrams, so that this balance shows an instantaneous comparison between the English and French weights within this range. The balance has a working capacity of eight ounces, and is sensitive to one-sixty-fourth grain. The torsion balance

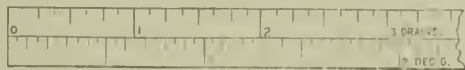


FIG. 22.

principle is capable of a great variety of applications in weighing machines, and the Springer Torsion Balance Company expect to bring out a number of other forms during the present year.

(The lecturer closed by exhibiting and explaining samples of torsion and other balances, and answering questions concerning them.)

THE IRON ORES OF THE UNITED STATES.

BY JOHN BIRKINBINE, Mining Engineer.

[*A Lecture delivered before the FRANKLIN INSTITUTE, December 9, 1887.*]

Mr. BIRKINBINE was introduced by the Secretary of the INSTITUTE and spoke as follows :

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN :

In considering the iron ores of the United States it is essential that we first note the sources from which come the supply of mineral consumed in the manufacture of 5,683,329 gross tons of pig iron in 1886 and 6,417,148 gross tons* of pig iron in 1887, as well as the ore used for fettling in rolling mills, the amount required for the production of blooms by direct processes, bloomeries and other purposes. Probably 11,500,000 gross tons of iron ore were used in this country in 1886, and the estimate for 1887 is 13,000,000 gross tons.

A careful investigation of the consumption of iron ore and the production of pig iron in the United States, shows that the average yield of ore as charged into the blast furnaces of the country is about fifty-one per cent., therefore a little less than two tons of ore are required on the average to produce one ton of pig iron. The output of 577 blast furnaces, in 1886 was, as above stated, 5,683,329 gross tons, requiring 11,300,000 gross tons of iron ore; but of this quantity probably 300,000 gross tons was mill cinder, which deducted, leaves 11,000,000 gross tons of iron ore used by our furnaces, to which we should add 500,000 gross tons consumed in bloomery fires, or used as fettling, or as flux in smelting the precious metals and other purposes, making a grand total

* Since the lecture was delivered, the statistics of iron and steel production in 1887, issued by the American Iron and Steel Association, have been published, and returns from some of the iron mines or mining districts have been obtained, therefore in the text the actual figures for 1887 are given in place of the estimates which were made in the lecture, and the year 1887 is mentioned as last year.

of 11,500,000 gross tons. Similar estimates give the probable consumption of iron ore in 1887 as 13,000,000 gross tons, of which nearly ten per cent. was foreign ore.

There is in northern New York and in some of the Southern States a limited industry where iron ores are converted into "loupes" and hammered into blooms in open "bloomary" fires, sometimes called "Catalan" forges, after the ancient method pursued in Catalonia, Spain. The amount of iron produced in this way in 1887 was but 15,088 net tons, or 13,471 gross tons. Various "direct" processes, which have been and are still being experimented upon, and upon which so much time and money have been expended with so little practical result, also used some ore. Our attention will be devoted entirely to smelting in the 583 blast furnaces of the country, the great bulk of our domestic iron ores, as well as the foreign ores brought into the United States.

There are to-day in the United States 676 blast furnaces, but ninety-three of these have been dropped from the official record by reason of having outlived their usefulness, or having failed to keep pace with the march of improvement, which raised our blast-furnace practice to a standard which commends the admiration of the world. This leaves a total of 583 blast furnaces on the active list.

COMPOSITION OF IRON ORES.

Enthusiasts or novices still occasionally claim an ore yielding eighty to ninety per cent. of iron in spite of the fact that the magnetic oxide or proto-sesquioxide of iron (Fe_3O_4), the base of our magnetites, and the richest ore which can be obtained consists of 72.4 per cent. iron and 27.6 per cent. oxygen; and the sesquioxide of iron or ferric oxide (Fe_2O_3), the base of all our hematites, is a combination of seventy per cent. iron and thirty per cent of oxygen. There is also the protoxide of iron or ferrous oxide (FeO), containing nearly seventy-eight per cent. of iron, but this does not exist in our ores except in combination, as in the carbonate of iron (FeOCO_2 or FeCO_3). However, all the ores are mixed with earthy or rock gangue and carry sulphur, phos-

phorous, manganese, titanium and more or less water, and seldom approximate theoretical purity. The most notable instances of this approach being in large crystals of magnetite from near Port Henry, N. Y., and Republic, Mich., and in the harder specular ores of Michigan and Minnesota.

Notwithstanding the high proportion of iron in magnetic oxide, the red hematites mined in this country are, as a class, the richest ores in iron which we produce. This is largely due to the dissemination of crystals of magnetic ore through the gangue, or their mixture with other crystals, requiring in many cases the reduction of the ore to small size, and the separation by gravitation or by magnetism of the particles.

The red hematites differ only from the brown hematites in the former carrying less water than the latter, and the subdivision of the brown hematites into "turgite," "goethite," "limonite" and "bog ore," etc., is mainly due to the water they contain, and the more or less intimate mixture of the peroxide and earthy matter. Of the red hematites the "specular," "micaceous," "dye stone," and "fossil" ores are determined by physical structure or association with gangue.

The carbonate iron ores are also classed as "siderite," "clay iron stone," "black band," "kidney ore," etc., in various localities.

The carbonates are based on the combination of carbonic acid and ferrous oxide, above referred to, and if existing pure as FeCO_3 would contain 48.27 per cent. of iron, but these generally occur in connection with carbonaceous matter.

DISTRIBUTION OF IRON ORES.

An enumeration of the localities from which American iron ores are obtained, and a discussion of the peculiarities of occurrence, formation or composition of the various ores, would require a course of lectures, and therefore in a single evening no attempt, other than to cover the ground generally, will be made. In twenty-six states and territories iron ores are now mined, and in most of the others deposits of mineral are known to exist in workable quantity.

In every state east of the Mississippi River, with the exception of Florida and Mississippi, iron ores have been or are now mined, and in Mississippi I lately inspected a weathered carbonate, covering considerable territory. A deposit of bog ore in Florida is now being investigated and plans for a blast furnace to utilize it, drawn. Of the other states, we immediately recognize Minnesota and Missouri as containing a wealth of excellent ores. Iowa and Arkansas, Louisiana and Texas have known deposits as yet undeveloped, although in the last named state some of the ores in the northeast section have been smelted. A sample of excellent brown hermatite, probably a weathered carbonate from near Council Bluffs, and a limonite from central Iowa, were lately received.

Of the Western States, Colorado, Utah, California, Oregon and Washington Territory have produced ores, and deposits of mineral are reported in other territories. In fact it would be unwise to assert that iron ore does not exist in workable deposits in any one of the political subdivisions of the United States, and our neighbors of Canada, Mexico and Cuba can boast of remarkable supplies of this mineral. Some of the Canadian iron ores have been exploited by American capital, the output being shipped into this country, and efforts are now being made to develop other deposits for home consumption. Mexico has its unrivalled iron mountain, the Cerro de Mercado, at Durango, and numerous minor deposits throughout the Republic, and the development of the iron ore on the south shore of the Island of Cuba, near Santiago de Cuba, in which some of our large steel companies are interested, is now well known.

In locating in a general way the deposits of iron ores no attempt will be made to point out on the map * those which have been reported as existing in the western portion of the continent, for but few have been worked, and information as to the numerous favorable showings is not sufficiently definite to be reliable. We may, however, note that an iron industry exists at Port Townsend, in Washington Territory,

* The lecturer indicated on a large map the general position of the various iron ores, and designated the position of the more prominent mining districts.

for which some ore is obtained locally, and some from Texada Island, British Columbia, and an English syndicate is now constructing a large steel plant at Seattle, Wash. T. At Osewego, Ore., and at Clipper Gap, Cal., there are blast furnaces (now inactive) but for which local brown hematites form the bases of supply. The most important Western development is at South Pueblo, Col., where various Colorado ores are smelted. Iron on a small scale has also been made in Utah, and considerable iron ore is used throughout the West in silver smelting. A general summary of the present exploited iron ore deposits east of the Rocky Mountains is as follows :

MAGNETITES.

Magnetites abound in Canada and occur in Maine, Vermont, New Hampshire and Rhode Island, but the most northerly deposits at present worked in quantity are in the Lake Champlain region. The Chateaugay, Port Henry and Crown Point mines, the most noted of these, lie from 1,200 to 2,000 feet above the lake, and from seven to thirty miles westward. Some magnetites have, however, been found close to Lake Champlain, and others are on the western slope of the Adirondack mountain range. A few of these ores are of the Bessemer grade, but it is believed that more can be made so by crushing the ore and separating the apatite (phosphate of lime) from the iron crystals. Concentration and separation is now carried on to a large extent, and the use of fine ore in the blast furnace is causing no serious trouble. Considerable magnetic ore sand is found along the coasts of California and Long Island Sound, some of which has been separated by magnetic machines, and it has been claimed that the sub-aqueous deposit from whence these sands emanate affect ship's compasses; in fact, Mr. Edison attributed the loss of the *Oregon* to such magnetic disturbances.

The Lake Champlain district produces about 500,000 tons per annum, and up to date is credited with having yielded 13,500,000 gross tons of ore, which has been smelted in blast furnaces or reduced by the direct process in bloomary fires. An area of one-half square mile west of Port Henry has, it is claimed, produced 3,500,000 gross tons of ore.

Some deposits of magnetite in northern New York, which indicate rich ore in quantity, carry so much titanium as to seriously interfere with their smelting in the present state of our knowledge of ore concentration and blast furnace practice, but this, like other drawbacks, will be overcome.

Magnetites occur again in southeastern New York, in Putnam and Orange Counties, within fifty miles of New York City, those of the former county, such as the Tilly Foster and Croton Mines, being prominent, owing to peculiarities of formation and composition. Some are apparently large lenses or chimneys of ore with faults, making mining expensive. The annual output of these mines approximates 45,000 tons.

Tracing the magnetites from southern New York into northern New Jersey, we find numerous mines in that state producing in the aggregate over 500,000 gross tons per annum, and having in their history added about 16,000,000 gross tons to our ore supply. Many of these ores are high in sulphur and require roasting. In northern New Jersey "franklinite" occurs. This is an ore containing zinc, manganese and iron which is smelted in small furnaces to produce "speiseleisen" after it has been roasted, to remove the zinc, as zinc oxide. Occasionally very large crystals (with faces of five inches) of franklinite are found. The Lake Champlain region has been worked since 1804, and the New Jersey magnetic mines have been producers for over a century.

Following the ranges of hills into Pennsylvania, the magnetic iron ores occur along the South Mountain, the prominent deposits in this state being at Boyertown, along French Creek, at Cornwall, and at Dillsburg. The Cornwall ore hills are worked above the water level, and are practically on elevated ground. The deposit is unique, consisting of a mass of magnetic ore, confined by trap walls forming three hills, and is mined more cheaply than any ore of similar grade in the country. The Cornwall ore, while sufficiently low in phosphorus for Bessemer steel purposes, carries, on an average, two per cent. of sulphur, which is partially removed by roasting in kilns with waste coal.

The Cornwall ore hills have been worked for over 150 years, and the aggregate output to date is 8,673,000 gross tons, of which 687,210 gross tons were mined in 1887.

The general topographical and geological structure continuing through Maryland, Virginia, North Carolina, South Carolina, Georgia, Alabama and Tennessee, magnetites are found in these states, the largest developments being in North Carolina, notably at the Cranberry mines in the western and a titaniferous deposit in the central portion of the state.

(It was in North Carolina that the first discovery of iron ores in this country was made three centuries ago, in 1585, but the first iron ore shipped from America came from Virginia in 1608.)

Ores exist in the western part of South Carolina, and a century ago smelting of these was introduced in that state, but for thirty years there has been no iron made there.

This general group of ores just mentioned comprises practically all the magnetites exploited east of the Rocky Mountains, except occasional deposits in the north peninsula of Michigan and in Missouri; in these cases the magnetites occur with specular red hematites.

With the exception of Cornwall and one or two other deposits the magnetites are mined underground, a depth of 300 to 800 feet having been obtained in some of the workings of the Lake Champlain, the New Jersey and the Pennsylvania mines. But few American magnetites are free from sulphur, phosphorus, copper or titanium.

RED HEMATITES.

The most important operations in mining red hematites are in the Lake Superior district, but to indicate the geographical distribution of this class of ores we may first trace them from northern New York, where a considerable industry has been maintained in mining specular ores, into central New York, where the fossil ores known as "Clinton fossils" are wrought. These latter occur again in Pennsylvania, near Danville, and extend through the central part of the state, supplying stock to numerous blast furnaces; then through

Maryland, Virginia and West Virginia into eastern Kentucky and Tennessee, being recognized in the latter state as "dystone ores," and showing their greatest development in Alabama and Georgia. These ores being the basis of supply for the Birmingham, Alabama, furnaces are there known as "Red Mountain" ore.

A peculiar and apparently isolated deposit of Clinton fossil ore exists at Iron Ridge, about fifty miles north of Milwaukee, Wis.; here the ore soon after mining breaks into grains which, from their shape, size and color, have given to it the name of "flaxseed ore." Another deposit of fossil ore is reported further north in Wisconsin. The Iron Ridge ore carries such proportions of phosphorus, lime, and silica, as to invite attention to it for use in producing steel by the basic process.

The Lake Superior red hematites are of the hard and soft varieties, the Marquette district of Michigan and the Vermilion district of Minnesota showing the former, and the Menominee and Gogebie districts of Michigan and Wisconsin exhibiting chiefly the softer varieties, although soft ores may occur among the harder and *vice versa*.

The noted deposits at Iron Mountain and Pilot Knob, Mo., are speculars with some magnetites, and in the central part of that state excellent soft, red hematites abound. Ores of this class are also reported in Arkansas and Texas. Many of the Bessemer ores of the United States are red hematites, but such ores low enough in phosphorus for this process are the exception rather than the rule. The purest of these ores command the highest market rates, being shipped fully 1,500 miles, in some cases by water and rail. The Chicago, Cleveland, Pittsburgh, Wheeling and adjacent blast furnaces depend principally upon the red hematites of the Lake Superior district, and large shipments are made to Troy, N. Y., and into eastern Pennsylvania.

One of the recognized conditions of an iron ore suitable for the manufacture of Bessemer pig iron is that it shall not contain over one part of phosphorus to 1,000 of iron, but there are cases where ores have been condemned because of an excess of phosphorus, or chemists have been blamed for imperfect analyses where neither the ore or the analyst were

at fault; but the fuel used in smelting the ore in the blast furnace or in melting the iron in a cupola was credited with low phosphorus when it carried a liberal amount; in fact, where low phosphorus is required it is as important to analyze the fuel as the ores or iron for this component.

BROWN HEMATITES.

The brown hematite ores are liberally distributed and are mined in most of the states. The earlier iron industry of the country was sustained principally from the bog variety along the sea-coast, but as the settlements extended westward the use of these lean ores was abandoned.

The Salisbury region, embracing portions of western Massachusetts and Connecticut and eastern New York, has an unrivalled reputation for pig-iron for special purposes produced from brown hematites. These ores also abound in the Lehigh, East Penn, Cumberland and other Pennsylvania valleys, passing thence into Maryland, through the Shenandoah, New River and Cripple Creek Valleys of Virginia into North Carolina, Tennessee, Kentucky and Alabama, forming in the latter the principal support of the charcoal iron-producing industry. To the brown hematites we owe much of the prominence Pennsylvania has won as an iron centre and from them our foundry irons, car-wheel metal, boiler plate and other specialties have been prepared. A widely distributed deposit of excellent brown hematite occurs in Northern Texas and Louisiana, and outcrops of what are apparently hematites along the Mississippi and Missouri and their tributaries in Mississippi, Tennessee, Missouri, Iowa, etc., are probably weathered carbonates.

Ores of this class are also obtained in Maine, in Rhode Island, on Staten Island, in Delaware, Maryland, Florida and other states.

The brown hematite often occurs in connection with the red hematite. As far as has been exploited, the richest ores of this class are in the Salisbury district, of New England, in southwest Virginia, middle Tennessee and Kentucky, northern Georgia and eastern Alabama, but some other deposits, but slightly developed, offer favorable indications as to quality.

CARBONATES.

The carbonate iron ores are generally esteemed as the least reliable of all varieties; they have been the main dependence of the Baltimore iron industry, and occur between Baltimore and Washington as kidneys in clay. They were the instigating cause of the establishment of our western Pennsylvania blast furnaces, as at Johnstown and in the Monongahela and Shenango Valleys. Ohio has few ores that are not carbonates and to these ores the large developments of the Mahoning Valley, the reputation of the Hanging Rock region and the sudden rise into prominence and nearly as sudden decline of the Hocking region is to be credited.

In using this variety of ore, it is generally roasted to drive off the carbonic acid, and other ores are often similarly treated to eliminate the sulphur they contain.

The carbonates are widely distributed and form an important factor in our iron production. They can be traced through New York, Pennsylvania, Ohio, West Virginia, Virginia, Kentucky and Tennessee, into Alabama and Mississippi, and are found in Arkansas, Missouri, Iowa, etc.

The black-band variety is used to a limited extent, but the cheerful outlook which encouraged a large investment of home and British capital to secure in this country similar results to those obtained from these ores in Scotland was not verified in practice.

MILL CINDER.

In the production of puddled and rolled iron, the resultant cinder which carries off silica, phosphorus, etc., contains from fifty to sixty per cent. iron, and this otherwise waste material is utilized in the manufacture of pig iron by mixing it with natural ores. Owing to prejudice its use is seldom referred to, and yet there are probably not over four mines in the country which contribute so much towards the manufacture of pig iron as this slag or cinder. In some portions of Germany, mill cinder is roasted before it is charged into the blast furnaces.

To a limited extent the residuum from iron pyrites (FeS), after the sulphuric acid is extracted, is used for the production of iron; this is commercially known as "purple ore," or "blue billy," and is employed in Great Britain more than in this country.

RÉSUMÉ.

It is not presumed that in this hasty sketch all of the iron ores east of the continental divide have been referred to, nor is it possible in the limited time at command to even enumerate the prominent features of the more important ones.*

As mined and supplied to our blast furnaces, the various classes of ores yield about as follows :

Magnetites, . . .	from 45 to 67 per cent iron.	Average 56 per cent.		
Specular and fossil ores (red hematites), . . .	" 35 to 68	" "	" 57	"
Brown hematites, . . .	" 35 to 55	" "	" 42	"
Carbonates, raw, . . .	" 25 to 40	" "	" 32	"
Mill cinder, ...			" 54	"
Foreign ores, ...			" 53	"

In 1884, the American Iron and Steel Association determined by careful investigation that, eliminating from the calculation the mill cinder used, the ore employed to produce pig iron in the United States averaged 2.03 tons per ton of iron made, being less than was required in other countries; Great Britain averaging 2.4 tons; Germany, 2.6 tons; France, 2.6, and Belgium, 2.7 tons. Since that time a larger proportion of richer ores have been employed in America and it is probable that our average consumption is slightly below two tons of ore per ton of pig iron.

It is perhaps unnecessary to remind you that the most important source of our ore supply is from the Lake Superior region, the output of the four districts embraced in it

* During the lecture a number of lantern slides were exhibited, reproductions of photographs of numerous prominent iron mines, showing the extent of the deposits and the methods of working them, etc. A geological and topographical model of the Cornwall ore hills of Pennsylvania was also shown.

being sufficient to produce forty per cent. of the pig iron which we make. About thirty-six per cent. of the iron ore mined in the United States in 1887 came from that region, and owing to the high percentage of iron in these ores, their aggregate, 4,667,652 gross tons, was sufficient to produce nearly forty-three per cent. of the pig iron made in the United States last year.

FOREIGN ORES.

Next to the Lake Superior region comes the foreign ores, 1,039,433 gross tons having been imported in 1886, and the returns for 1887 show that we received 1,194,301 gross tons. Some of these ores come from our neighbors in Canada and Cuba, but the major portion was from Spain, Africa, the Island of Elba, Greece, France and other countries across the ocean. Notwithstanding the fact that the United States imported more largely than ever before in 1886, and a still greater amount in 1887, the proportionate quantity of foreign ores per ton of pig iron made was, until 1887, less than in 1881, and we to-day use relatively less foreign ores than any of the prominent iron producing countries, as is exhibited by the following table.

Iron production and iron ore imports in different countries in eight years:

UNITED STATES.

<i>Years.</i>	<i>Pig Iron Made.</i>	<i>Iron Ore Imported.</i>	<i>Average Amount of Ore Imported per Ton of Iron Produced.</i>
1879, ...	2,741,853	284,141	'104
1880, ...	3,835,191	493,408	'129
1881, ...	4,144,254	782,887	'189
1882, ...	4,623,323	589,655	'128
1883, ...	4,595,510	490,875	'107
1884, ...	4,097,868	487,820	'109
1885, ...	4,044,526	390,786	'086
1886, ...	5,683,329	1,039,433	'183
Total, ...	33,765,854	4,559,005	'135
1887, ...	6,417,418	1,194,301	'183

GREAT BRITAIN.

<i>Years.</i>	<i>Pig Iron Made.</i>	<i>Iron Ore Imported.</i>	<i>Average Amount of Ore Imported per Ton of Iron Produced.</i>
1879, ...	5,995,337	1,083,692	'181
1880, ...	7,749,233	2,634,401	'340
1881, ...	8,377,364	2,449,277	'292
1882, ...	8,493,287	3,282,496	'386
1883, ...	8,490,224	3,178,310	'321
1884, ...	7,528,966	2,728,672	'362
1885, ...	7,250,657	2,817,597	'389
1886, ...	6,870,665	2,875,176	'418
Total, ...	60,755,733	21,097,621	'346

FRANCE.

<i>Years.</i>	<i>Pig Iron Made.</i>	<i>Iron Ore Imported.</i>	<i>Average Amount of Ore Imported per Ton of Iron Produced.</i>
1879, ...	1,400,286	941,812	'673
1880, ...	1,733,102	1,168,215	'674
1881, ...	1,894,861	1,287,870	'680
1882, ...	2,039,067	1,425,870	'699
1883, ...	2,069,430	1,601,217	'774
1884, ...	1,855,247	1,412,724	'762
1885, ...	1,630,648	1,419,521	'871
1886, ...	1,507,850	1,158,581	'768
Total, ...	14,130,491	10,415,810	'737

GERMANY.

<i>Years.</i>	<i>Pig Iron Made.</i>	<i>Iron Ore Imported.</i>	<i>Average Amount of Ore Imported per Ton of Iron Produced.</i>
1879, ...	2,226,587	380,000	'171
1880, ...	2,729,038	607,007	'222
1881, ...	2,914,009	615,490	'211
1882, ...	3,380,806	785,360	'232
1883, ...	3,469,719	800,373	'231
1884, ...	3,600,612	980,442	'272
1885, ...	3,687,316	852,714	'232
1886, ...	3,339,803	812,635	'243
Total, ...	25,347,890	5,834,029	'230

BELGIUM.

Years.	Pig Iron Made.	Iron Ore Imported.	Average Amount of Ore Imported per Ton of Iron Produced
1879, ...	448,371	614,534	1'373
1880, ...	595,704	921,784	1'548
1881, ...	624,736	1,169,206	1'872
1882, ...	727,000	1,206,717	1'66
1883, ...	783,433	1,612,469	2'058
1884, ...	750,812	1,488,140	1'982
1885, ...	712,876	1,393,601	1'96
1886, ...	697,110	1,365,939	1'959
Total, ...	5,340,042	9,772,390	1'83

This table demonstrates that, although our importation of iron ore reached its maximum in 1887, the amount of foreign ore used closely approximated in 1886 the proportion used in Great Britain in 1879, since which date that country has continued to rely on foreign ores to a much greater extent than the United States. The same remark holds true concerning Germany, and France has been more dependent upon foreign ores than any of the countries named, except Belgium, which relies almost entirely upon ores mined outside of its borders.

Taking the average of eight years for the United States, Great Britain and France, Belgium and Germany, and assuming that the average yield of ore, as reported by Mr. Swank, from actual returns made by our blast furnaces in 1884, holds good for the entire period, we have the following:

	United States.	Great Britain.	France.	Germany.	Belgium.
Tons of ore required to make one ton of pig iron, . . .	2'03	2'4	2'6	2'6	2'7
Tons of foreign ore imported per ton of pig iron made, .	1'35	1'346	1'737	1'230	1'83
Average percentage of foreign ore to total ore used, . . .	6'65	14'33	28'37	8'85	67'78

From this it is evident that the United States not only uses a less proportion of foreign ore than any of the other countries named, but the product of our domestic mines averages so well that we need less ore per ton of pig iron than other countries.

We can justly attribute a part of this showing to the influence of the specific duty of seventy-five cents per ton on foreign ores, which undoubtedly encourages a higher average percentage than would be the case if a lower or an *ad valorem* duty was laid on the ores. In fact, we now receive chiefly the best of the foreign ores, for the more valuable the material the lower the proportionate charge for duty.

PROMINENT IRON ORE PRODUCERS.

Next to the foreign ores, the Cornwall ore hills of Pennsylvania ranks as a source of supply and the company operating this unique deposit, which in 1887 mined 667,210 gross tons of magnetite, is the largest producer of iron ore in the country.

The Lake Champlain district follows next, and the product of the mines of magnetic ore sent from Plattsburgh, Port Henry and Crown Point aggregating, in 1886, 663,752 gross tons, and in 1887, 788,084 gross tons.*

To show the relative importance of the various regions, the following statement has been prepared. In it the output of the four districts, comprising the Lake Superior region, are given separately, and each region is placed in the order of its prominence in 1886. Where data were at hand the actual output, and in other cases estimates of the probable production of 1887 are given:

SOURCE OF IRON ORE SUPPLY BY DISTRICTS.

	GROSS TONS.	
	1886.	1887.
Marquette District, Lake Superior Region, .	1,621,887	1,836,953
Imported Iron Ores, ...	1,039,433	1,194,301
Menominee District, Lake Superior Region, .	880,006	1,198,743
Gogebic District, Lake Superior Region, .	756,281	1,237,704
Cornwall Ore Hills, Pennsylvania, . . .	688,054	667,210
Lake Champlain magnetites, ...	663,752	788,084
New Jersey magnetites, ...	500,501	547,889
Missouri mines, ...	379,776	427,785
Ohio ores, carbonates and hematites, . . .	344,480	377,465
Vermilion Lake District, Minnesota, . . .	304,396	394,252
Cranberry Mines, North Carolina, . . .	24,106	45,032

* Messrs. Witherbees, Sherman & Co., the largest individual firm of ore producers in the country, offer for sale, in 1888, 375,000 tons of ore from the mines near Port Henry, N. Y.

The following estimates are based upon an average yield of ore and pig iron production in 1886:

	GROSS TO S.	
	1886.	1887.
Alabama, ...	670,000	740,000
Tennessee, ...	470,000	600,000
Virginia, ...	380,000	450,000
Georgia, ...	95,000	105,000

It will be noticed that the Gogebic range outstripped the Menominee range in 1887, owing to the unusual activity in opening mines, and that the Lake Champlain district shipped more ore than the Cornwall Ore Hills in 1887.

The following shows the approximate total production of iron ore to date in prominent mining centres.

Lake Superior Region (thirty-two years), ...	35,700,000
Of which Marquette District supplied, ...	25,200,000
" Menominee " " 	7,500,000
" Gogebic " " 	2,000,000
" Vermilion " " 	1,000,000

Lake Champlain Region, N. Y. (eighty-four years), ...	13,500,000
Of which Port Henry supplied,*	8,000,000
" Crown Point " 	1,500,000
" Chateaugay " 	2,000,000
" Other mines " 	2,000,000

New Jersey (about 100 years), ...	16,000,000
Cornwall (about 140 years), ...	7,900,000
Missouri, ...	
Iron Mountain supplied, ...	2,750,000
Pilot Knob and other mines, ...	1,250,000

From the Chapin, Norway and Vulcan mines were won nearly one-half of the product of the Menominee range. While almost seventy per cent. of the output of the Gogebic range came from the Colby, Norrie, Ashland and Aurora mines.

TONNAGE.

The mining of iron is a business of considerable importance, and to appreciate its volume we may estimate the

* Six Marquette mines, viz: Lake Superior, Cleveland, Republic, Jackson, Champion and New York produced over sixty per cent. of the total output of this district.

railroad traffic which it represents, although all of the ore does not pass over railroads and much of it reaches the blast furnaces by both rail and water transportation. The majority of the ores from the Lake Superior region are carried by rail to shipping ports, thence by vessel to the lower lake ports and there re-handled into cars which travel over the railroads to the blast furnaces. Several blast furnace plants are located so as to unload foreign ores at their docks, but most of the foreign ore is transported from the ports where received by railroad cars or by lighters to the points of consumption. A number of our iron works also rely largely on the local deposits, from which the ore is carried by wagons or carts or by wire rope transmission or by tramroad to the furnaces. The proportion, however, of ore which is not hauled over our systems of railroads is quite small, and an illustration of the volume of business based upon the tonnage is a proper one.

Allowing an average load of fifteen net tons per car, which is more probably above than below the actual average, the amount of ore consumed in 1887, viz: 13,063,439 long tons or 14,631,052 net tons, would require 975,404 cars to carry it, or say 32,514 trains of thirty cars each, five such trains, with motive-power and caboose would occupy one mile of track when standing close together, or the year's product would occupy 6,503 miles of track, a distance equal to twice that from New York to San Francisco.

If all this traffic passed a given point there would be eighty-nine trains per day or a train every sixteen minutes during the year.

The traffic of the Pennsylvania Railroad in 1887, as exhibited by the annual report, shows a total tonnage of through freight of 6,278,628 long tons or less than one-half of the total amount of iron ore as above, and the local freight (43,754,669 long tons) is about three times as great, so that the iron ore carried by the different railroads in the United States in 1887 would represent nearly thirty per cent. of the entire freight traffic of the Pennsylvania Railroad and branches for the year.

If now we estimate the labor required to mine the ore, load it on cars, and transport it to destination, we see the importance of this industry, which employs over 50,000 men. But the mechanical appliances used are features of interest, and the hoisting engines, pumps, air compressors, rock-drills, washers and jigs connected with our mines have greatly influenced the advance in mechanical skill which has marked the development of our country.

The tabulated figures presented in this paper indicate the sources from which much of the iron ore is obtained, and from these figures we find that, of the estimated output of iron ore in 1887, the following approximate percentage came from

	<i>Percentage of total output.</i>
Lake Superior Region, ...	37 —
Foreign ores, ...	9
Alabama, estimated, ...	6 —
Cornwall Ore Hills, Pennsylvania, ...	5
Lake Champlain District, ...	6
Tennessee, estimated, ...	5 —
Ohio, ...	3
New Jersey, ...	4
Virginia, ...	4 $\frac{1}{2}$
Missouri, ...	3 $\frac{1}{2}$
Salisbury Region, ...	1 —
Georgia, estimated, ...	1 —

From these figures an approximate estimate of the value represented by the iron ore shipment of any one source of supply can be made. As the ores vary in the yield of iron, it will be of interest to place them in something near their relative rank by estimating the probable percentage of the total amount of pig iron which these ores produced.

	<i>Per cent.</i>
Lake Superior ores, ...	44
Foreign ores, ...	10 $\frac{1}{2}$
Lake Champlain ores, ...	6 $\frac{1}{2}$
Cornwall ores, ...	5 —
Alabama ores, ...	5 —
New Jersey ores, ...	4 $\frac{1}{2}$
Tennessee ores, ...	4
Missouri ores, ...	3 $\frac{1}{2}$
Virginia ores, ...	3 —
Ohio ores, ...	2 $\frac{1}{2}$
Salisbury Region, ...	1 —
Georgia ores, ...	$\frac{1}{2}$ —

The strikes in the anthracite coal regions and in the coke regions during the year, materially reduced the demand for ores, and curtailed the output of some of the important Eastern districts, such as the Lake Champlain, Cornwall and New Jersey mines.

The bulk of the hematites of Pennsylvania, of which we still have large deposits, are but little inferior in the yield of iron, and many are otherwise superior to the Southern ores, and our magnetites and those near us in New Jersey, together with the facility of drawing upon the Lake Superior and foreign countries for their best ores, place Pennsylvania in position to hold her status, and the question of the Keystone State maintaining its pre-eminence as an iron producer, rests entirely with those who manage and control its furnaces.

A BROADER FIELD FOR THE UNITED STATES GEOLOGICAL SURVEY.

BY PROF. PERSIFOR FRAZER.

Science of May 18, 1888, devotes its first article to a proposition said to be now pending before Congress "to enable the United States Geological Survey to carry on the agricultural work provided for by law." It mentions editorially that "This work falls properly under the scope of a geological survey, as in this case it requires only little additional work to the topographical and geological surveys that are continuously going on, while under any other department it would require the organization of a new survey, and involve great expense." This will commend itself at once to the judgment of all readers. For instance, when Mr. Walcott is pursuing his studies of the first and second faunerocks in the wilds of Massachusetts, Vermont, New York and Connecticut, it would but need the addition of an agriculturist to his corps of assistants, to enable him to supplement his very interesting information concerning the Lower Cretaceous, by adding that in the much disputed part of the

Taconic area, that disintegration into soil which obscured the real geological sequence from the late Dr. Ebenezer Emmons, is highly conducive to the production of winter wheat and early rose potatoes.

Indeed, it is likely that many of the United States geologists are as expert at horticulture, forestry and agriculture as in the science of which they are the accredited representatives of this country, and many a tedious page of stratigraphy and paleontology might be brightened by sprinkling flowers and ferns over it. In the far West, not only among the arid lands (already described as such by the Director, to the great benefit of our citizens), but on the summits of the most inaccessible peaks, and in the smiling grass valleys, hundreds of miles from any railroad station, the adaptability of the soil for truck gardening, strawberry and peach raising, and the like, might raise a mountain of doubt and uncertainty from the minds of intending immigrants.

The tendency towards consolidation is always a tendency towards economy, and in this case the merging of these very nearly allied investigations is merely forestalling a possible movement on the part of the proposed agricultural department (also pending before Congress) to join to the work of the botanical explorers the duty of settling the distracting questions of the subdivisions of the Archean, the place of the Taconic, and the desirability of a Quaternary Group, to their other researches. Of course it would entail only a little additional work on their part to do this.

Although the statement is not made in explicit terms, it is probable that the United States Geological Survey has neither enough to do nor a sufficient appropriation to do it with. As to the latter, will it be credited that its entire annual expenses, including the printing of the splendid volumes which other nations envy us so much, amount to considerably less than a million of dollars a year? What is this for a country like ours, the broadest in longitude under the sun, and so peculiarly constituted that no sequence in terranes in one part is repeated in any other part, and (according to the conclusions of some of our most frequently quoted geologists) no correlation is possible even between the series of

contiguous areas, not to speak of such remote districts as the Atlantic border, the Mississippi basin, the Rocky Mountain plateau, and the Pacific coast? It follows from this that the United States Geological Survey must establish separate columns—biotic and stratigraphic—wherever these can be found; and as there are thirty-eight states and eleven territories and each state has a number of counties, varying from 175 in Texas to three in Delaware, the possible number of such schemes of classification might reach 1,900.

It is said "possible," because it may turn out that in some cases the scheme of classification established for one county may, with little or no modification, be applied to another; but this cannot be known until the United States Geological Survey has examined them all, and this will require a very long time, owing to their number, and the meagre, not to say parsimonious, appropriation of the Government. It might be thought that the State Surveys could, in their little way, help to reduce this time, and to obviate, so to speak, the necessity for so much Governmental work; but in practice it has been found that no solution of any important question has been satisfactorily reached until the Government officers had been on the ground. At first sight there seems to have been an exception to this in the case of Prof. Dana's work on the Taconic, but this is only apparent; for although the final decision of the official survey was indeed in conformity with the views of the Nestor of American Geology, it was only after it had passed through several successive phases, and consumed several years of unremitting labor, all of which were required before it could be known that Prof. Dana *was* right.

Now that the United States Geological Survey has extended its field of study over the entire United States, including the states with, as well as those without surveys, the conclusion reached by every survey should be submitted to a like test, and this work can scarcely be accomplished in less than a century or two.

But it seems quite reasonable to extend the principle of con-association of the Government scientific work—a sort of syntaxonomy, as it would probably be denominated if

undertaken—still further. If there be an evident appropriateness in collocating the study of the disintegrated rocks with that of the uses of the resulting soil; so (proceeding in the opposite direction) must there be also in uniting with this study that of the orbs which are passing through the various phases already traversed by the little object which is the subject of the investigation of the geologist. In other words, is it not restricting the usefulness of the best equipped and supported organization for scientific purposes under our Government, simply to give it the earth for its study?

Why not transfer the Astronomical Bureau also to it? With only a little additional work the tables of computations for the nautical almanac could be made by the United States Geological Survey, and consistency would be secured by having the broad realm, first pointed out by La Place in all the transformations of its wonderful endogenesis, made the task of one national body to explore and expound, both in its abstract and in its economical relations.

Of course it would follow that navigation, which deals with the problems of travel upon the soft rock forming two-thirds of our little planet, would appropriately fall into one subdivision of the work of the expanded service; and as the Navy Department is entirely dependent upon navigation, this would cease to be necessary as a separate arm of the Government; for the fighting part of this Department could be transferred to a new Military Department, which would find plenty of occupation in protecting parties of explorers against hostile Indians, and standing guard over the geodetic signals which would be erected by the new Survey after its natural and necessary absorption of the Coast and Geodetic Survey within itself.

At least so far in the scheme of centralization we could confidently go, assured of a better and cheaper administration of all their cognate branches by the able Direction, which has hitherto been confined to geology alone.

It may be doubted whether it would be desirable for the present to go farther, but if subsequent events seemed to justify the step, only a little additional work would be needed to enable the reconstructed Geological Survey to supply us

with a Congress to pass appropriations for its maintenance, to build bridges and railroads to help transport its corps, and even to manufacture whatever Nature might seem to have neglected for the purpose of elucidating the Cosmos, and applying it to the needs of the new Survey's constituency—man.

P. F.

THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE FOLLOWING DEFINITION OF TEMPERATURE, NAMELY: THE TEMPERATURE OF A BODY IS REPRESENTED BY THE LENGTH OF THE CALORIFIC OSCILLATIONS OF ITS MOLECULES. BY RAOUL PICTET.*

TRANSLATED BY CHIEF ENGINEER ISHERWOOD, U. S. NAVY.

If heat is admitted to be purely and simply the manifestation of the molecular forces possessed by the particles of bodies, there must necessarily also be admitted that the mechanical work transmuted into the calorific movement displaces these particles from their position of equilibrium and causes them to move in elliptical paths whose amplitude is proportional to the work transmuted.

At the absolute zero of temperature there is no oscillation of the particles and their cohesion is *maximum*; but at a certain temperature, measurable for each body, the oscillation is *maximum* and the body, disaggregating, melts, the molecules swinging sufficiently apart to lose the condition of stable equilibrium.

In this hypothesis, the absolute contact of the material particles is rendered impossible by the action of the ether. That the attraction of matter for the ether does not follow the same law as the attraction of matter for matter, is admitted; and across insensible distances the attraction of

* *Comptes Rendus*, 1879; volume 88; page 805.

matter for the ether exceeds the attraction of matter for itself.

In these conditions the *repulsive forces* vanish, and there would exist in nature only the *attractive forces*.

On the above bases let there be considered the action produced by external work done upon a body supposed to be at the absolute zero. Each particle oscillates from an exterior extreme position to another limited interior position. Evidently, the result of this molecular movement will be an augmentation of the volume of the body *pro rata* to the *mean length* of the oscillations of the elementary particles of the body.

The *coefficient of dilatation* will then be in proportion to the number of molecules contained in the body, either with the volume in which the molecules are contained, or finally with the physical forces which the calorific movement puts into action.

Now the two following postulates can be admitted :

The laws of the attraction of matter for matter are absolutely general and universal.

The phenomena of disaggregation of bodies are subject to these laws.

These being premised, and calling N the number of molecules contained in unity of length of a solid body; designating by l' and l the lengths of the oscillations corresponding to the temperatures t' and t ; and letting a be the coefficient of the dilatation of the solid body; the following equation evidently results, namely :

$$\int_l^{l'} N \, dl = \int_t^{t'} a \, dt.$$

Now N is determined by the density and the atomic weight of the body.

As in one cubic metre there are $\frac{d}{p}$ particles — calling d the density and p the atomic weight—we have, in order to obtain the number of molecules N , that is to say, the

number of molecules contained in the linear unit or edge of the cube,

$$N = \sqrt[3]{\frac{d}{p}}.$$

Taking a for the dilatation measured between zero and 100° Centigrade, there is directly obtained the relation

$$l_{100} - l_0 = \frac{a}{\sqrt[3]{\frac{d}{p}}}$$

which gives the value of the augmentation of the length of calorific oscillation when the temperature increases from zero to 100° .

Now, if the attraction of matter for matter obeys a general law, each solid molecule should divide into two or more liquid molecules when the oscillations became equal to a certain *maximum*.

Two physical laws would then be confirmed, which are the inevitable consequences of these deductions, namely:

(1) *The higher the melting point of a solid, the shorter are the molecular oscillations.*

(2) *The melting points of solids correspond to the lengths of equal oscillations: the products of the lengths of the oscillations by the melting points should be a constant number for all bodies.*

These two laws are verified as closely as the experimental determinations of the different elements which enter into the foregoing equations permit.

TABLE OF THE LENGTHS OF CALORIFIC OSCILLATIONS OF SOME SOLIDS, AND OF THE PRODUCTS OF THESE LENGTHS BY THE MELTING POINTS OF THE SOLIDS IN CENTIGRADE DEGREES ABOVE THE ABSOLUTE ZERO.

Names of the Solids.	Atomic Weight. p	Density d	Values of a (Dilatation between 0° and 100°)	Lengths of Oscillation.	Melting Points of the Solids in Centigrade Degrees above the Absolute Zero t .	$t \times \frac{a}{\sqrt[3]{\frac{d}{p}}}$
				$\frac{a}{\sqrt[3]{\frac{d}{p}}}$		
Selenium, . .	39.75	4.30	0.00368	0.007725	490	3.7854
Lead, . . .	104	11.35	0.0028657	0.005382	608	3.272
Zinc, . . .	32.7	7.19	0.002942	0.004873	723	3.523
Silver, . . .	54	10.60	0.00193	0.003077	1250	3.841
Copper, . . .	31.75	8.90	0.001715	0.0026215	1323	3.468
Gold, . . .	98	19.26	0.001466	0.0025205	1373	3.459
Iron, . . .	28	7.79	0.0011717	0.0017805	1873	3.340
Platinum, . .	198.5	21.53	0.0008842	0.001854	1973	3.658

The foregoing table contains the metals whose coefficients of dilatation are known with sufficient accuracy for the purpose of testing the truth of the laws.

The above table shows that the lengths of the oscillations are in the inverse ratio of the melting points, and that the products of these quantities are sensibly constant. The two laws above indicated are consequently correct, and temperature is really represented by the length of oscillation of the molecules of solid bodies.

Analogous equations involve the elements of volatile liquids when compared at their boiling points.

ON SOME EARLY FORMS OF ELECTRIC FURNACES.

No. 9. WATT'S ELECTRIC FURNACES.

BY PROF. EDWIN J. HOUSTON.

At the meeting of the Royal Society in London, on November 19, 1807, Sir Humphrey Davy gave a description of the methods employed by him in his classic experiments on the electrical decomposition of the fixed alkalies. The paper in which this announcement was made was published in the *Philosophical Transactions* for 1808.

Since the electric furnaces described in this number, as well as some of the forms contained in several of the preceding numbers, are dependent for their operation on electrical principles, first discovered, or applied to such purposes by Davy, a brief prefatory account of his processes may not be without interest.

Davy was the pioneer in all electrolytic decompositions of saline salts rendered conducting by the action of heat. Solids, originally non-conductors, acquire the power of electrolytic conduction, when heated to the point of fusion.

Davy first tried to electrically decompose saturated aqueous solutions of the alkalies, but failed, and correctly ascribed the cause of such failure to the decomposition of the water.

Quoting from the Transactions of 1808, he writes :

"The presence of water appearing to prevent any decomposition, I used potash in igneous fusion. By means of a stream of oxygen gas, from a gasometer, applied to the flame of a spirit lamp, which was thrown on a platina spoon containing potash, this alkali was kept for some minutes in a strong red heat and in a state of perfect fluidity. The spoon was preserved in communication with the positive side of the battery of the power of 100 of 6 inches, highly charged; and the connection from the negative side was made by a platina wire."

By the aid of this arrangement Davy succeeded in obtaining potassium, the derivation of which from potash he showed synthetically by allowing it to be oxidized by exposure to the air.

In order to eliminate the effects of the atmosphere, Davy confined the fused potash in glass tubes, into which the decomposing current was led by platinum wire, hermetically inserted in the glass. Such a structure formed in fact a species of early electric furnace. It was not, however, practical for continuous working, since the glass tube was rapidly corroded by the action of the highly heated alkali.

In 1851, Charles Watt, of England, took out letters-patent No. 13,755 of 1851, in Great Britain, for "Improvements in the decomposition of saline and other substances, and in separating their component parts, or some of them, from each other, etc., etc." In the specification of these letters-patent, Watt describes a number of applications of electricity for metallurgical operations.

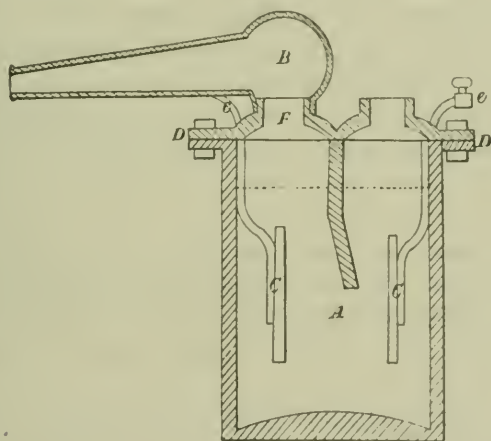
In one of these processes, he describes an apparatus suitable for the electrolytic decomposition of metallic salts of such metals as are readily volatilized at comparatively low temperatures. In order to render the salt an electrolyte, it is placed in a suitably shaped vessel provided with terminals or electrodes, and subjected to a temperature not only sufficiently high to fuse the same, but also to volatilize the metal as soon as it is separated by the action of the current.

Watt describes this form of furnace or electrolyzing cell in the specification of the above English patent. We append a quotation preferably to a condensed statement of the same, so as to avoid reading into the description the knowledge of the present day.

"The second part of my invention consists of a mode of preparing or obtaining the metals of the alkalies and alkaline earths by the united action of electricity and heat. For performing this part of my invention, by the united action of electricity and heat, I employ a vessel of the form shown in *Fig. 5*, which is made of iron, or other suitable material,

Section

FIG. 5.



capable of bearing a full red heat. In this figure, *A*, is the vessel which should be at least half an inch thick, and if made of iron, previously to its being used, should be coated over its exterior with clay or other substance to preserve it from the action of the fire; *B*, movable head for the collection of the metals; *C*, electrodes, with their attachments *e*; *D*, flanges to support the vessel upon the furnace. The covered compartment *F*, being that in which it is intended to eliminate the metals, is supplied with a carbon electrode, and the uncovered compartment is supplied with a gold electrode; but I wish it to be understood that I do not restrict myself

to the particular form of apparatus, or to the material to be used for electrodes. The vessel is filled with dry saline matter, so that when it is in a state of fusion it shall reach the dotted line; the partition keeps the eliminated substances from reacting upon each other, and also excludes the air from the compartment in which the metal is eliminated, the access of which would cause the metals to be oxidized. The vessel is placed in a furnace, where it can be subjected to the action of a full red heat, and when the saline matter is in a state of fusion, contact is made between the decomposing vessel, and should at least be equal to that which would be supplied by ten cells of Daniell's battery arranged for intensity, but, of course, this depends on the nature of the salt that is being decomposed. The fused salt is maintained at that temperature which will ensure the instantaneous volatilization of the metal, as it is eliminated, and a proper receiver (such as is usually employed for the preparation of such metals will answer) is connected air-tight with the narrow tube projecting from the head. The metal is received and preserved in any convenient fluid hydrocarbon."

Watt's apparatus, as will be observed, is clearly a modification of Davy's. It is an improvement thereon, however, in that it describes means for collecting the metal as evolved, and is, therefore, to a certain extent, a partially continuous process.

It would appear quite feasible to construct on the general line of the Watt furnace, or electrolytic bath, a continuous process for the electrical production of sodium or other volatile metal. Such a device would require the following parts, viz :

(1) A suitable electrolyzing chamber for the reception of the fused salt.

(2) Electrodes, the character of which would vary with the metal to be decomposed, though for most purposes carbon would be suitable.

(3) Hoods covering the electrolyzing chamber and placed over the negative and positive electrodes respectively, connected with suitable pipes for the collection of the volatil-

ized metal and the electro-negative constituent of the fused and electrolyzed salt. When so desired the collection of these substances may be aided by the action of a suitable pump, that maintains a partial vacuum or diminished pressure on the surface of the electrolyzing chamber.

(4) An accessory chamber containing a store of salt, fused or unfused, that may automatically, or at stated intervals, be allowed to communicate with the electrolyzing bath and so maintain the level of the fused salt therein.

(5) Suitable means for maintaining the salt to be electrolyzed in a fused state. This heat may be either of ordinary origin, or it may be electrical.

I would propose the following as a practicable plan for readily obtaining a high temperature in a limited space, by the action of electrical currents, viz: employ an inverted induction coil; send rapidly alternating currents through the primary coils of comparatively high resistance and great length, and thus induce in the secondary coils of low resistance and short length enormous currents of great heating power, such as are used in electric welding. Such currents could be employed to produce the comparatively low temperatures required in connection with the apparatus proposed above, by causing them to traverse and heat to incandescence coils of wire surrounding the space or vessel to be heated, or to produce more intense temperatures by the action of voltaic arcs that are caused to play directly on the furnace or space to be heated. They would appear to be particularly suited to such metallurgical processes where different fusions are to be effected.

The device proposed would possess the advantages of being readily obtained in a limited space, and of producing the highest temperatures possible. The ease with which ordinary smelting operations could be carried on in all locations within reach of an alternating-current circuit, even on a comparatively extended scale, is evident.

Devices for regulating the intensity of the heat so produced, by either regulating the current that passes, or the magnetic resistance of the inverted induction coil by whose agency it is produced, could readily be arranged.

In all forms of electric furnaces heretofore described, where the reduction of metallic substances is effected by the heat of the voltaic arc alone, and where electrolysis has no part in the reaction, voltaic arcs produced by the passage of rapidly alternating currents through inverted induction coils could readily be employed. Indeed it is possible, that in many cases where the action of the electricity is believed to be mainly of an electrolytic nature, experiment would show that the action is rather the chemical action of the intensely heated carbon electrodes, thus extending the field of action of heat produced by alternating current arcs.

Watt also describes in the specification of the above mentioned patent a process for the electrical separation of alloys of metals suitable for the refining of gold and silver waste.

CENTRAL HIGH SCHOOL.

PHILADELPHIA, May 5, 1888.

THE INFLUENCE OF ALUMINIUM UPON CAST IRON.*

BY W. J. KEEP, C.E., PROF. C. F. MABERY, S.D., AND L. D. VORCE.

Aluminium is a metal obtained from its oxide alumina. It is white in color and very tenacious, and it alloys readily with iron. Cast iron ordinarily used is iron which contains all the carbon that it could absorb during its reduction in the blast furnace. This carbon, when found in chemical union with the iron, is called combined carbon. In this state it cannot be seen. It is also found mechanically mixed with the iron in the form of graphitic carbon, when it becomes visible. Other elements commonly found in cast iron are phosphorus, sulphur, manganese and silicon. The natural condition of carbon in iron is the combined state. The presence of silicon drives a portion of the carbon into the graphitic state.

*A Paper read by W. J. Keep, Detroit, Mich., at the Cleveland meeting of the American Association for the Advancement of Science.

Sulphur, manganese and phosphorus do not cause the carbon to leave its natural combined state, and if silicon be present, these elements either drive it out or overpower it. Carbon is therefore a passive element, and is made to change its form by the presence of other elements. It is this change of carbon which indicates to the eye the influence of any element upon the cast iron. Iron and combined carbon or carburetted iron is called white iron, and the grain is generally very fine, and often even, and the metal is very hard. Graphite darkens the fracture until it becomes a very dark gray, and the grain is coarse and irregular. With increase of graphite the metal becomes soft. We shall confine ourselves in this paper to the influence of aluminium upon cast iron.

Let us, for a moment, review the present knowledge on this subject. It is known that fused wrought iron, a mixture of cast iron and steel, or steel alone, either of which would make castings which would be full of blow-holes, will make solid and homogeneous castings if as small a quantity of aluminium as one-tenth of one per cent. is added just before pouring. Also that such addition causes the iron to remain fluid long enough to allow its being cast into moulds. It seems to be the general opinion that the aluminium does not remain in the metal, but that it exerts its influence between the time of its introduction and the time of its departure. This seems to be the sum total of the present information regarding the influence of aluminium upon iron.

We propose in this paper to give the results of a series of very carefully conducted tests, to further substantiate the statements just made, and to settle the question as to whether aluminium remains in the casting. Also to determine the influence of this metal upon the physical structure, and upon the composition of iron. The physical tests that we have employed are what are known as "Keep's Tests," and by them we are enabled to make apparent to the eye the influence of any element upon cast iron.

When it was understood that we were to undertake this examination, the Cowles Electric Smelting and Aluminium

Company kindly furnished us with what ferro-aluminium we needed, and Prof. C. F. Mabery and L. D. Vorce volunteered to undertake the chemical examination of the test bars. The results of these investigations will be appreciated when it is understood that we began without the least expectation of the very important results we have obtained, and that the methods for the determination of minute quantities of aluminium were so imperfect that the small quantities used in the "Mitis" process could not be determined, if they still remained in the castings.

Regarding the physical tests, we should state that we use two bases, one a white iron, with composition Si 3.86, Al 11.42, P .263, S .0307, Mn .092. The other, a gray Swedish iron marked FLM, with composition Si 1.249, P .084, S .04, Mn .187. The ferro-aluminium contained silicon.

The melting was done in a covered plumbago crucible, in a coke furnace driven by a blast of two and a quarter ounces. The test bars were one foot long and cast in pairs, one being half an inch square, and its mate one-tenth of an inch thick and one inch wide.

We started with thirty pounds of the base in the crucible. At the first heat there were cast four pairs of bars from the base alone, which took five pounds of metal. After allowing the remaining metal to become solid, we returned the runners of the first cast, and added four pounds of the base, and returned the crucible to the furnace. When nearly melted we added enough ferro-aluminium to bring the percentage of aluminium in the whole to where we wished it, for the second set of bars. We proceeded in like manner through the entire series of heats. To arrive at the influence of the aluminium, we made another series of heats, with the same base, with exactly the same conditions, only we did not add the aluminium.

The difference between the two series of tests gives the effect of the aluminium.

We shall consider this subject under the following heads: (1) The solidity of castings, and the prevention of blow-holes. (2) Does the aluminium remain in the iron to exert an influence when the iron is remelted? (3) The effect

of aluminium upon the grain, or the changing of the carbon from the combined to the graphitic state. (4) The taking away the tendency to chill. (5) The prevention of sand scale. (6) The effect upon hardness. (7) The resistance to a load suddenly applied, or a dead weight. (8) The resistance to a load suddenly applied, impact. (9) The elasticity. (10) Permanent set. (11) The effect on the shrinkage of the iron. (12) The fluidity of the melted metal.

(1) THE SOLIDITY OF CASTINGS, AND THE PREVENTION OF BLOW-HOLES.

All of our tests bear upon this subject, but we have made one test, using the white base iron, and one-tenth of one per cent. of aluminium. It is almost impossible to get a solid casting of the white base alone, and its resistance to weight is generally about 175 pounds for the half inch square bars, and its resistance to impact is about 100 pounds. We have obtained, however, exceptionally sound castings of this base, and we shall use the strength of such castings for comparison.

These sound castings of the white base alone resisted a weight of 379 pounds. With one-tenth of one per cent. of aluminium added, it resisted 545 pounds, a gain of 166 pounds, or about forty-four per cent., from this small addition. Measuring the resistance to impact the white alone was 289 pounds, with aluminium 254 pounds, or about six per cent. gain. The castings appear of slightly finer grain, and the character of the crystallization is somewhat different, but the secret of the strength lies in the closing of space between the grains, or, in other words, in the increased solidity of the casting. No other change is noticeable in the metal.

A graphic representation of this test is not needed.

(2) DOES THE ALUMINIUM REMAIN IN THE IRON TO EXERT AN INFLUENCE WHEN THE IRON IS REMELTED? (*Fig. 1.*)

To determine this we made a series of six heats from the white base, and added to the first heat one-fourth of one per cent. of aluminium. This amount alters the grain very perceptibly, making it whiter and finer, and removing

the tendency of the base to a slight specular appearance and giving a homogeneous fracture. It increases the strength above the base about twenty per cent. to resist weight, and for impact an increase of over seventy per cent. The next heat was a remelt of the first, with the runners of the first cast put back, and enough white base added to reduce the aluminium to two-tenths of one per cent. when the second cast was made.

Our comparison will now be made between this series and the comparison series of the base alone. Looking at the chart, we see that the effect of the aluminium in the second heat is greater than it was in the first case to which heat the aluminium was added. This is due to the increasing porosity at each heat of the base when melted alone, and to the solidity of the series with aluminium. At the third and subsequent heats the same result is apparent, the remaining aluminium causing more solid castings, though the continued additions of white iron at each heat, and the consequent lessening of aluminium, render the castings less strong at each re-melting. Yet the effect of the aluminium is so constantly apparent at each melt, as to leave no doubt as to the presence even in the sixth re-melting. The chart which we have prepared shows those effects, both as to weight and impact.

As we proceed with the description of other tests, it will be noticed that we add but a small quantity of aluminium at each heat, and depend upon the additions made at previous heats to bring up the required percentage.

The results of the tests show conclusively that the aluminium remains and exerts its influence in subsequent casts as fully as would be expected.

(3) THE EFFECT OF THE ALUMINIUM UPON THE GRAIN, OR THE CHANGING OF CARBON FROM THE COMBINED TO THE GRAPHITIC STATE.

Let us say a few words in regard to the way in which, and the reason why, carbon takes on the graphitic form. All of the carbon, both combined and graphitic, which the iron is capable of holding when solid, must be dissolved

and exist as combined carbon in the melted iron. Cast iron made in the usual way contains all of the carbon that it can hold. Very often cast iron, when melted, contains more carbon than it can hold in combination when at a lower temperature; if so, as the iron cools down, such excess of carbon will separate as graphite and rise to the surface. In any case when a melted iron contains more carbon than the iron can hold in combination when cold, all of the excess will not be able to reach the surface, though it may not be visible in the casting to the eye. The introduction of other elements into the melted metal may alter its ability to hold the carbon. Sulphur causes it to let some go, while manganese enables it to hold more carbon in solution. Silicon also somewhat diminishes the capacity of the molten metal to retain carbon while it is liquid.

Aluminium allows most of the carbon to retain its natural combined form until the metal is too thick for the separated carbon to escape, but at the instant of solidifying aluminium causes the iron to drop a portion of its carbon from the combined state. This liberated carbon takes the graphitic form, and is imprisoned in the otherwise solid iron. The advantage arising from a change of carbon from the combined to the graphitic state at the instant of crystallization is that all the carbon thus liberated is imprisoned uniformly throughout the casting, and is not accumulated in pockets forming soft and hollow spots, as would be the case if liberated while the casting was yet fluid. Aluminium, more than any other known element, accomplished this. It not only changed white iron to gray, but seemed at once to change the whole character of the metal. The drop of carbon seems to be instantaneous, at the instant of crystallization, and for this reason the time taken in cooling has little effect. In fact, when the aluminium obtains full control of the carbon it would seem that the more sudden the cooling the more the formation of the graphite, and the thin portions of the casting are therefore as gray as the thicker portions. The powerful and positive influence of aluminium upon the carbon, and therefore upon the grain and color of the iron, is shown by an

examination of the samples. Take those made from the white iron base, with almost no silicon present. The base alone gives a white bar full of blow-holes. An addition of one-quarter of one per cent. aluminium gives us not only a perfectly homogeneous and solid casting, but the color is darker, and the grain shows that some of the carbon has taken the graphitic form. The thin casting shows this even more than the heavier bar, showing that the change occurred suddenly, and that time had but little effect. Examining such bar in turn, we see that each similar addition of aluminium produces a corresponding effect, until at the third addition, or three-fourths of one per cent., the casting is gray with no sign of white, either in the square or in the thin bar.

The set of tests with the gray iron base, containing one and one-quarter per cent. of silicon, shows that silicon and aluminium work together in the same direction, and that a slight addition of aluminium takes the white out of the casting at once, giving the same grain in a thin as in a thick casting.

This effect increases as the aluminium increases, and the indications are that at least up to four per cent., the limit of our experiments, the more aluminium, the softer and grayer the castings.

4. THE TAKING AWAY THE TENDENCY TO CHILL. (*Fig. 2.*)

If cast iron be cooled very suddenly, the carbon, which the melted metal holds in combination will not have time to separate, and will be retained in the combined state. Such castings are called chilled castings. Chill is caused by molten iron running against a body which rapidly withdraws its heat, causing it to retain its carbon in the combined form. Back from the chill, where this instantaneous cooling could not exert its full effect, a portion of the carbon takes the graphitic form. This property is made use of when it is desirable to obtain hard wearing surfaces, and in the same casting tough and soft central portions, as in car wheels. While this chilling effect is exceedingly valuable for many purposes, yet, generally speaking, the founder desires exactly the reverse.

We have said that aluminium causes the carbon to assume the graphitic form on the instant of solidifying, and therefore the sudden abstraction of heat does not imprison the combined carbon and cause chill.

This effect of aluminium is to give a uniform grain for thick and thin castings, and not allow the coldness of the mould to affect the grain.

5. THE THICKNESS OF SAND SCALE.

This is an important consideration, for the sand must be cleaned from the casting, and the surface must first be cut before the interior can be reached. To prevent the iron from burning the sand into itself, and thus forming a scale, a plumbago facing is sifted on the surface of the mould, but it is difficult for the facing to lie on the surfaces, or to resist the intense heat of the metal. When aluminium in an iron causes the dropping of the graphite from the mass of the metal, that graphite which is on the surface of the casting separates and forms a perfect plumbago facing, which opposes the sand and the heat. It will therefore be seen that in castings having sufficient aluminium to cause this separation of graphite, there will be no sand clinging to the face, and that the surface will be soft as the interior of the casting. Every iron-worker will appreciate this good effect of aluminium.

6. THE EFFECT UPON HARDNESS.

Hardness in cast iron is caused by the carburetted or white iron in masses large enough to oppose the tool. If the carburetted iron exists in minute threads stretched around atoms of graphite, a tool will easily cut it, and it will not be considered hard. This graphitic carbon, minutely dividing the mass, gives the tools of the workman a chance to cut or break the films of metal, giving what we call softness to the iron. The later the carbon is dropped the smaller will be the atoms of graphite and the closer the grain. Yet this greater subdivision will, for the reason just given, make the iron work more easily. The fineness of the grain of iron affected by aluminium causes such iron to be much more easily cut than iron of coarser grain.

The power of wrought iron and steel to resist extension is so great that where such stresses are to be resisted, decarbonized metal should be used. The resistance of any cast iron to crushing is so great that we need not consider this. The forces which cast-iron structures should be made to resist, aside from crushing, are a dead weight, or a blow applied transversely. We should therefore test cast iron with these forces.

7. RESISTANCE TO A LOAD GRADUALLY APPLIED OR A DEAD WEIGHT. (*Fig. 3.*)

If we compare the transverse breaking weights of the two series which we have been considering, number by number, we perceive that the aluminium has increased the strength to sustain a constant load. This is a very important effect, and, perhaps, comes partially from the tenacity and strength of aluminium itself, but probably more from the uniform grain of the iron.

8. RESISTANCE TO A LOAD SUDDENLY APPLIED OR IMPACT. (*Fig. 4.*)

It may be thought that the effect is substantially the same, whether the force be a constant weight or a suddenly-applied blow. We shall at a future time prove that the effects are not the same, and that an iron should be tested by a blow if it is expected to resist impact. By a comparison of the graphic representation, we see that the capacity to resist impact is increased by the addition of aluminium much more than the capacity to resist a dead weight. It will be seen at a glance that the test bars made with the white base are benefited far more than those made with the gray base. The reason for this is, that the white base alone made porous castings; at each remelt this porosity increased, due to the continuation of the heat, running the strength down to sixty-eight pounds at the fifth heat. The first and each subsequent addition of aluminium caused the castings to be perfectly sound, and the infinitesimal atoms of graphite deposited throughout the metal removed the rigidity and brittleness of the initial metal.

FIG. 1.

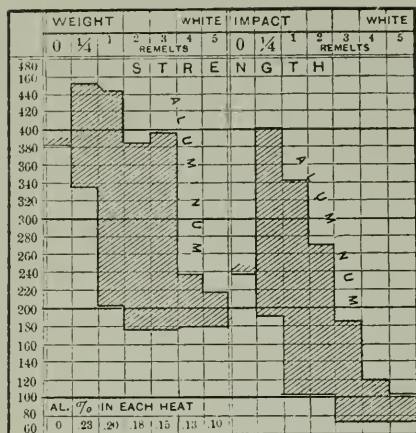


FIG. 2.

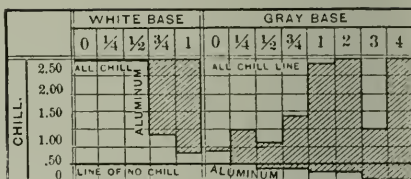


FIG. 3.

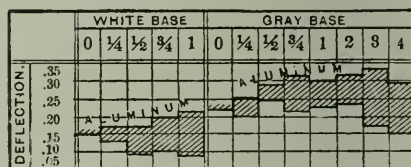


FIG. 4.

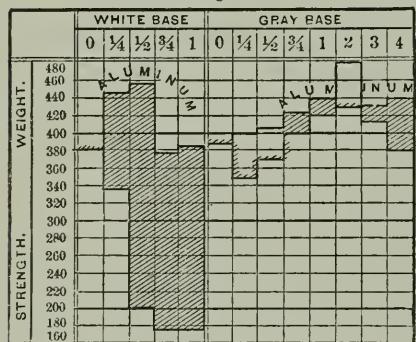


FIG. 6.

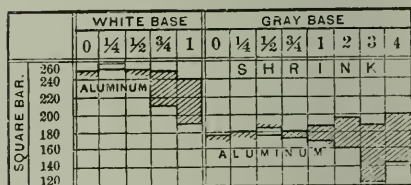


FIG. 7.

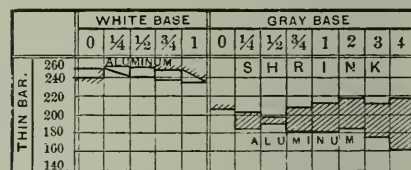
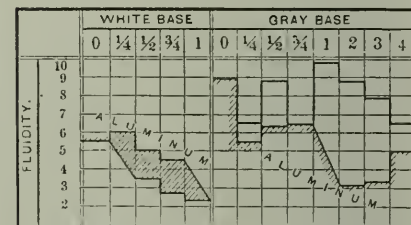


FIG. 8.



The gray iron base contained enough silicon to accomplish all this, and the only effect on strength that the action of the aluminium on carbon could have, would be to increase the fineness of the grain, unless the toughness of the aluminium itself could give strength to the casting, though the aluminium, no doubt, removed any slight blow-holes that existed in the initial gray metal. This leads us to notice that each addition of aluminium increases the strength over that of the initial metal. We must expect that after we have added enough aluminium to cause a solid casting and to remove the brittleness which the dividing up of the mass by the atoms of graphite accomplishes, any further additions of aluminium, and consequent increase of graphite (which has no strength of itself) must weaken the casting.

9. ELASTICITY. (*Fig. 5.*)

The compactness and closeness of the grain of cast iron, when aluminium was the agent by which the graphite was precipitated, and the fine attenuation of the veins of iron and combined carbon, cause the metal to be very elastic, and, as we have seen, not so brittle as without aluminium.

10. PERMANENT SET.

This is caused by the compression of the graphite within the framework of iron and combined carbon. When this compression of graphitic carbon is produced by transverse bending the framework of the metal also takes on a permanent form, which cannot be altered, except by a greater force than was before applied. The fineness and compactness of iron alloyed with aluminium gives less permanent set than iron equally as soft when such softness is produced by silicon.

11. THE EFFECT ON THE SHRINKAGE OF THE IRON.

The more suddenly and completely the carbon is changed from combined to graphitic at the instant of the crystallization, the more space will the casting occupy. When the casting is cold it will, therefore, have contracted less than if more carbon had remained combined. White iron, having

most of its carbon in the combined state, shrinks from one-fourth to one-third of an inch in each foot. Gray iron sometimes shrinks as little as one-tenth of an inch to each linear foot. As the combined is the natural state for the carbon, we may say that this maximum shrinkage is the natural shrinkage for cast iron having its carbon combined. We can, therefore, say that aluminium takes out or reduces shrinkage. This is a very great advantage, as shrinkage, when a sufficient quantity is added, requires great skill in the preparation of patterns to prevent warping and cracking and violent internal strains within the castings. The lessening of shrinkage avoids these evils, and is therefore a great gain.

Looking at chart (*Fig. 6*), for shrinkage, we see the most conclusive proof of our explanation of the way in which shrinkage is lessened. With both the white and the gray bases, during the first two additions the shrinkage of the square bar is slightly increased. The influence of the aluminium thus far has been in the direction of elimination of blow-holes and causing an even distribution of the dark and light grains. At the third addition, however, when the amount reached three-fourths of one per cent., the effect was appreciably felt upon the carbon, as seen by the color, and as we should expect, from the deposition of this large bulk of graphite, the casting does not shrink as much, and, each addition of aluminium, increasing this bulk of graphite, decreases the shrinkage.

The effect upon the grain and color of the thin bars of the series (*Fig. 7*) is very remarkable, showing that the aluminium has changed enough carbon to graphite to produce a dark even-grained casting. The effect upon the shrinkage of thin bars is as we should expect, and is more marked even than in the square bars. The shrinkage in thin bars of the white series shows a constant decrease as the aluminium increases, but in the series for comparison, the shrinkage dropped still more rapidly. If a new crucible were used in commencing this comparison series, enough silicon might have been absorbed to produce this effect. This leads us to remark that on account of the variations of

conditions in any series of tests, that cannot be foreseen, we must avoid drawing any but general conclusions, and these should be based upon a large number of experiments.

12. THE FLUIDITY OF THE MELTED METAL. (*Fig. 8.*)

Our tests of fluidity are correct as far as each individual heat is concerned, but variation may be due to the heat of the metal of that particular cast when poured. Viewed in a general way, the indications are that with the white base, with almost no silicon, the aluminium has increased the fluidity; judging from the series with the gray base, we would say that combined with silicon, aluminium reduced the fluidity, but later tests show that the aluminium, to a very marked degree, increases the fluidity.

Our remarks in connection with shrinkage show that a sharp casting is produced by the instantaneous dropping of graphite when crystallization takes place, and that if the iron is fluid enough to fill the mould any extra fluidity causes the iron in shrinking to draw away from the mould. Again, the percentage of aluminium necessary to bring about these desirable results will be too small to have much effect upon the fluidity of the metal.

The fact of the iron giving sharper and more perfect castings, caused by the deposition of graphite at the instant of solidification, might cause the iron to be pronounced more fluid, if judged by the appearance of the castings. No doubt the presence of varying quantities of manganese, sulphur, phosphorus and silicon in the cast iron used would modify the influence of aluminium, and until this is understood it may require considerable experiment to determine the amount of aluminium required or how it shall be introduced.

This hurried presentation of the remarkable effects of aluminium upon cast iron will give an idea of the great benefit which is now promised to the iron founder by the rapidly falling price of aluminium as cheapened by the electric furnace.

GENERAL THEORY OF JOINTED BOW GIRDERS.

BY E. A. WERNER, C.E.

(Continued from Vol. cxxvi, page 63.)

EXAMPLE.

CIRCULAR ARCH.

As an example, I have calculated in the following a stiffened truss, with a *circular* line of thrust, of 150' feet span, divided into 10 panels of 15 feet each, and 50 feet depth of bow, or height of top joint above the abutment joints.

I will state here that I selected the example on purpose, from the point of view only, to introduce the reader as much as possible into the novelties of the bow structures and not with the intention to give a standard model truss.

The truss is supposed to carry one track of a railroad, the road lying 25 feet above the abutments.

It is furthermore supposed that the *upper chord takes up completely and fully* the thrust of the bow.

As loads are assumed :

Own weight (iron and track), . . . = 18,000 pounds.

Moving load, 3,000 pounds p. l. f., . = 45,000 "

63,000 pounds per

panel point.

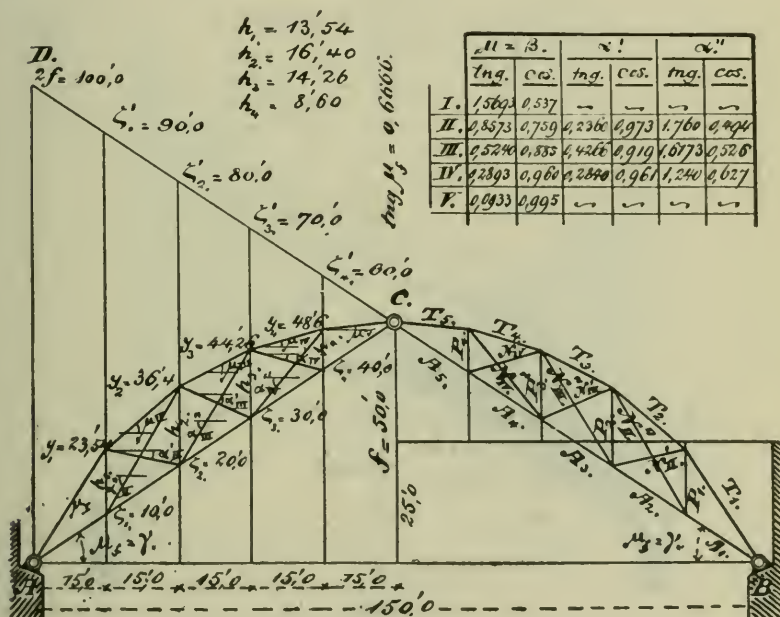
The loads—own weight and moving loads—are considered as taken up *both* in the same panel points. If it should be preferred to distribute the own weight over the panel points of both chords, *P* only would change, and the necessary correction can be easily made.

The calculation is made so, as if every panel point always were completely loaded. In fact, this is not the case, as the panel points on the beginning and the end of the loaded parts will not be loaded

fully. This way of calculating gives generally somewhat greater strains, but it shows exactly the division lines. Still, in a concrete example, it will always be good to calculate the values of $G_1 G_2 G_3$, according to the special specifications.

DATA OF CALCULATION.

The following diagram gives all the data necessary for calculation:



$$\left(\frac{\zeta' - y}{2fh}\right)_1 = \frac{11.40}{860} = 0.01325$$

$$\left(\frac{\zeta + y}{2fh}\right)_1 = \frac{33.54}{1354} = 0.02477$$

$$\left(\frac{\zeta + y}{2fh}\right)_2 = \frac{56.4}{1640} = 0.03439$$

$$\left(\frac{\zeta + y}{2fh}\right)_3 = \frac{74.26}{1426} = 0.05207$$

$$\left(\frac{\zeta + y}{2fh}\right)_4 = \frac{88.6}{860} = 0.10302$$

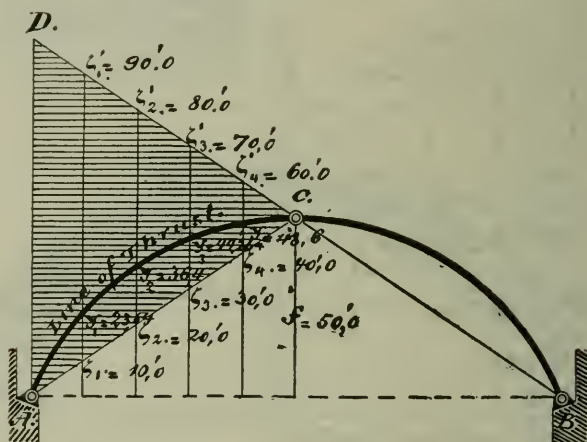


FIG. 2.

$$\left(\frac{\zeta - y}{2fh}\right)_1 = -\frac{13.54}{1354} = -0.01$$

$$\left(\frac{\zeta - y}{2fh}\right)_2 = -\frac{16.4}{1640} = -0.01$$

$$\left(\frac{\zeta - y}{2fh}\right)_3 = -\frac{14.26}{1426} = -0.01$$

$$\left(\frac{\zeta - y}{2fh}\right)_4 = -\frac{8.6}{860} = -0.01$$

$$\left(\frac{x}{h}\right)_1 = \frac{15}{1354} = 1.10783$$

$$\left(\frac{x}{h}\right)_2 = \frac{30}{1640} = 1.82927$$

$$\left(\frac{x}{h}\right)_3 = \frac{45}{1426} = 3.15568$$

$$\left(\frac{x}{h}\right)_4 = \frac{60}{860} = 6.97674$$

U.

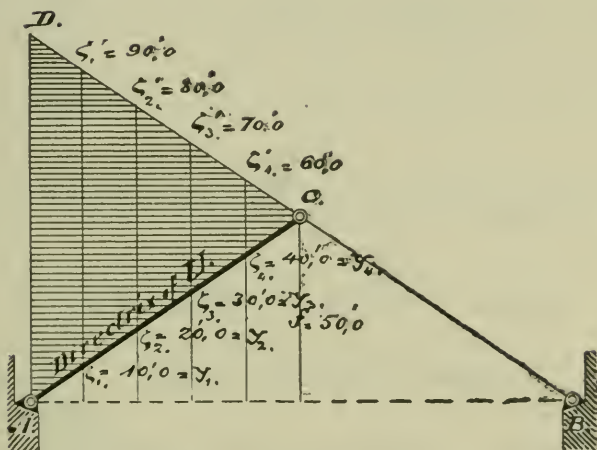


FIG. 3.

$$\left(\frac{\zeta' - y}{2fh}\right)_1 = \frac{80}{1354} = 0.05908$$

$$\left(\frac{\zeta' - y}{2fh}\right)_2 = \frac{60}{1640} = 0.03659$$

$$\left(\frac{\zeta' - y}{2fh}\right)_3 = \frac{40}{1426} = 0.02805$$

$$\left(\frac{\zeta' - y}{2fh}\right)_4 = \frac{20}{860} = 0.02305$$

$$y = \zeta$$

$$\left(\frac{\zeta + y}{2fh}\right)_1 = \frac{20}{1354} = 0.01477$$

$$\left(\frac{\zeta + y}{2fh}\right)_2 = \frac{40}{1640} = 0.02439$$

$$\left(\frac{\xi + y}{2fh}\right)_3 = \frac{60}{1426} = 0.04207$$

$$\left(\frac{\xi + y}{2fh}\right)_4 = \frac{80}{860} = 0.09302$$

$$\left(\frac{\xi - y}{2fh}\right) \text{ is equal to zero.}$$

Check. The coefficients of $\left(\frac{M}{h}\right)$ and U are different by the value of $a_h b_h c_h$ of $H = \frac{1}{2f} = 0.01$

W .

$$\left(\frac{M}{h}\right)_2 = 0.02659 + (1.82927 - 0.03439) - 0.01$$

$$\left(\frac{M}{h}\right)_1 = 0.04908 + (1.10783 - 0.02477) - 0.01$$

$$- 0.02249 + (0.72144 - 0.00962) = W_{II}$$

$$\left(\frac{M}{h}\right)_3 = 0.01805 + (0.15568 - 0.0527) - 0.01$$

$$\left(\frac{M}{h}\right)_2 = 0.02659 + (1.8292 - 0.03439) - 0.01$$

$$- 0.00854 + (1.32641 - 0.01768) = W_{III}$$

$$\left(\frac{M}{h}\right)_4 = 0.02325 + (6.97674 - 0.10302) - 0.01$$

$$\left(\frac{M}{h}\right)_3 = 0.02805 + (1.35568 - 0.05207) - 0.01$$

$$- 0.00480 + (3.82106 - 0.05095) = W_{IV}$$

Check. The same values of W are obtained in using either $\left(\frac{M}{h}\right)$ or U .

GENERAL EQUATIONS OF $\left(\frac{M}{h}\right)$, U , W AND MAXIMAL AND MINIMAL VALUES OF THESE EXPRESSIONS.

$$\left(\frac{M}{h}\right)$$

$$\left(\frac{M}{h}\right)_1 = 0.04908 G_1 g_1 + G_2 (1.10783 - 0.02477 g_2) - 0.01 G_3 (l - g_3)$$

$$\left(\frac{M}{h}\right)_2 = 0.02659 G_1 g_1 + G_2 (1.82927 - 0.03439 g_2) - 0.01 G_3 (l - g_3)$$

$$\left(\frac{M}{h}\right)_3 = 0.01805 G_1 g_1 + G_2 (3.15568 - 0.05207 g_2) - 0.01 G_3 (l - g_3)$$

$$\left(\frac{M}{h}\right)_4 = 0.01325 G_1 g_1 + G_2 (6.97674 - 0.10302 g_2) - 0.01 G_3 (l - g_3)$$

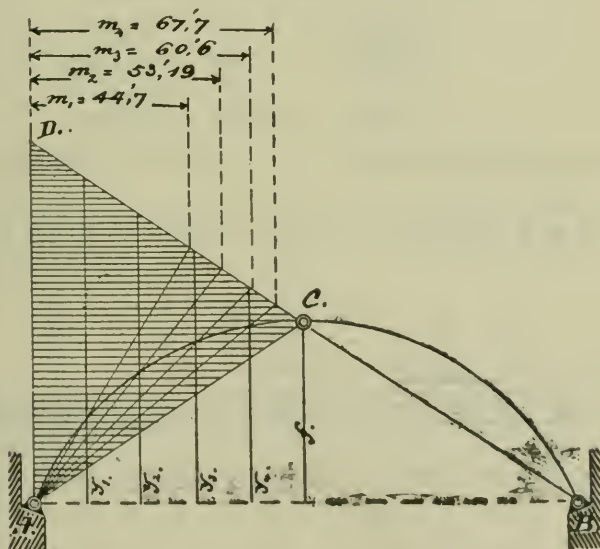
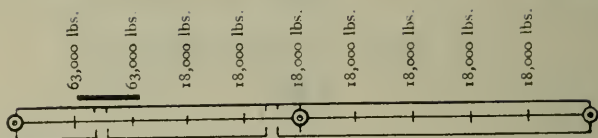


FIG. 4.

Fig. 4 gives graphically the maximum line of G_2 . The same values are found from $h = 0$.

The positions of the loads corresponding to the maximal and minimal values of $\left(\frac{M}{h}\right)$ and their numeric values are thus :

MAXIMA.



$$0.04908 G_1 g_1 = 0.04908 (63,000 \times 15) = 46,300$$

$$63,000 \times 30 = 1,890,000$$

$$\left. \begin{array}{l} 18,000 \times 45 \\ 18,000 \times 60 \end{array} \right\} = 1,890,000$$

$$G_2 = 99,000$$

$$3,780,000 (99,000$$

$$38.1818 = g_2$$

$$38.1818 \times 0.02477 = 0.94572$$

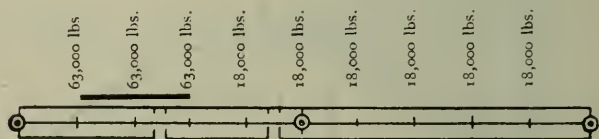
$$1.10783$$

$$0.94572$$

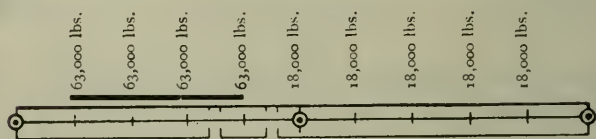
$$0.16211 \times 99,000 = 16,100$$

$$0.01 G_3 (l - g_3) = (15 \times 15 \times 18,000) \times 0.01 = 40,500$$

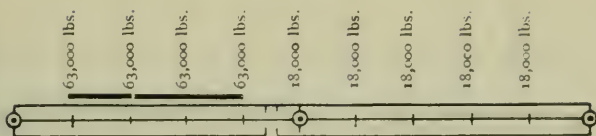
$$\left(\frac{M}{h} \right)_1 = 46,300 + 16,100 - 40,500 = 21,900 \text{ lbs.}$$



$$\left(\frac{M}{h} \right)_2 = 73,400 + 13,600 - 40,500 = 46,500 \text{ lbs.}$$

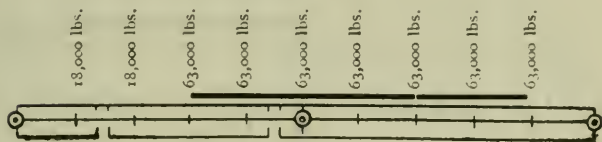


$$\left(\frac{M}{h} \right)_3 = 102,000 + 2,000 - 40,500 = 63,500 \text{ lbs.}$$



$$\left(\frac{M}{h}\right)_4 = 125,200 - 40,500 = 84,700 \text{ lbs.}$$

MINIMA.



$$0.04908 G_1 g_1 = (18,000 \times 15) \times 0.04908 = 13,200$$

$$18,000 \times 30 = 540,000$$

$$\left. \begin{array}{l} 63,000 \times 45 \\ 63,000 \times 60 \end{array} \right\} = 6,615,000$$

$$G_2 = 144,000$$

$$7,155,000(144,000$$

$$49.6875 = g_2$$

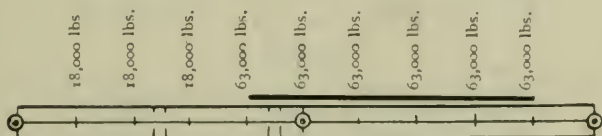
$$- 49.6875 \times 0.02477 = - 1.23076$$

$$1.10783$$

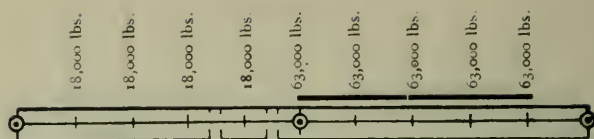
$$- 0.12293 \times 144,000 = - 17,600$$

$$G_3 (l - g_3) \times 0.01 = 0.01 (15 \times 15 \times 63) = 141,800$$

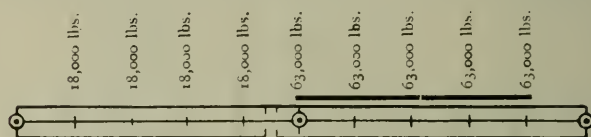
$$\left(\frac{M}{h}\right)_1 = + 13,200 - 17,600 - 141,800 = - 146,200 \text{ lbs.}$$



$$\left(\frac{M}{h}\right)_2 = + 21,600 - 9,800 - 141,800 = - 130,000 \text{ lbs.}$$



$$\left(\frac{M}{h}\right)_3 = + 29,200 + 600 - 141,800 = - 112,000 \text{ lbs.}$$



$$\left(\frac{M}{h}\right)_4 = + 35,800 - 141,800 = - 106,000 \text{ lbs.}$$

U

$$U_1 = 0.05908 G_1 g_1 + G_2 (1.10783 - 0.01477 g_2)$$

$$U_2 = 0.03659 G_1 g_1 + G_2 (1.82927 - 0.02439 g_2)$$

$$U_3 = 0.02805 G_1 g_1 + G_2 (3.15568 - 0.04207 g_2)$$

$$U_4 = 0.02325 G_1 g_1 + G_2 (6.97674 - 0.09302 g_2)$$

The maximal and minimal values are reached with full loaded and empty girder, the line $A C$ being directrix of U .

The divisions of $G_1 G_2 G_3$ in U correspond to the divisions of

$$\left(\frac{M}{h}\right)$$

MAXIMA.

$$U_1 = 55,800 + 83,600 = 139,600 \text{ lbs.}$$

$$U_2 = 103,800 + 69,100 = 172,900 \text{ lbs.}$$

$$U_3 = 159,000 + 39,800 = 198,800 \text{ lbs.}$$

$$U_4 = 219,800 = 219,800 \text{ lbs.}$$

MINIMA.

$$U_1 = 15,900 + 23,900 = 39,800 \text{ lbs.}$$

$$U_2 = 29,600 + 19,800 = 49,400 \text{ lbs.}$$

$$U_3 = 45,400 + 11,400 = 56,800 \text{ lbs.}$$

$$U_4 = 62,800 = 62,800 \text{ lbs.}$$

W

$$W_{II} = -0.02249 G_1 g_1 + G_2 (0.72144 - 0.00962 g_2)$$

$$w_2 = 75.1 \dots ft.$$

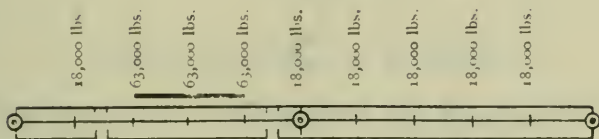
$$W_{III} = -0.00854 G_1 g_1 + G_2 (1.32641 - 0.01768 g_2)$$

$$w_3 = 75.1 \dots ft.$$

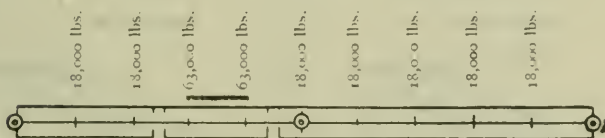
$$W_{IV} = -0.00480 G_1 g_1 + G_2 (3.82106 - 0.05095 g_2)$$

$$w_4 = 75.1 \dots ft.$$

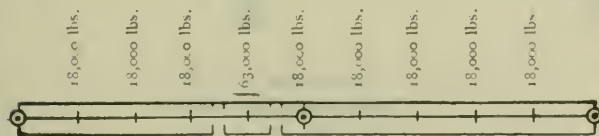
MAXIMA.



$$W_{II} = -6,100 + 54,500 = +48,400 lbs.$$

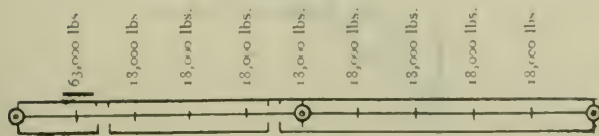


$$W_{III} = -6,900 + 50,200 = +43,300 lbs.$$

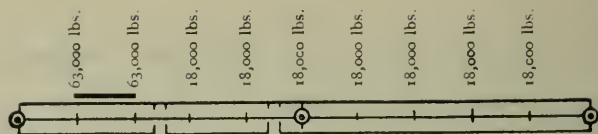


$$W_{IV} = -7,800 + 48,100 = +40,300 lbs.$$

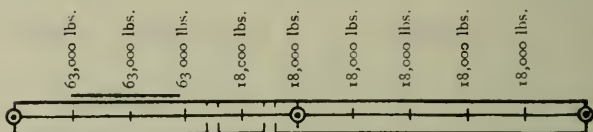
MINIMA.



$$W_{II} = -21,300 + 15,600 = -5,700 lbs.$$



$$W_{III} = - 24,200 + 14,300 = - 9,900 \text{ lbs.}$$

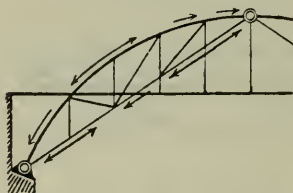


$$W_{IV} = - 13,400 \text{ lbs.}$$

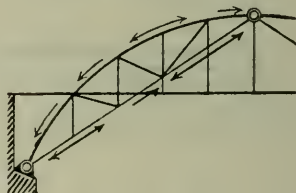
STRAINS A OF THE LOWER CHORD.

The course of the ties corresponding to the positions of the loads inducing the maximal and minimal values of $\left(\frac{M}{h}\right)$ are:

loaded 1-2.



loaded 1-3.

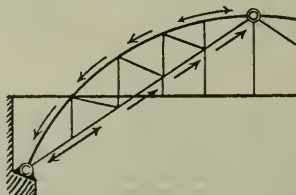


loaded 3-9.

loaded 4-9.

loaded 5-9.

loaded 1-4.



Hence the numeric values of A .

MAXIMA.

$$A_1 = A_2 = \frac{219,000}{0.832} = + 27,000 \text{ lbs.}$$

$$A_3 = \frac{48,500}{0.832} = + 59,000 \text{ lbs.}$$

$$A_4 = \frac{63,800}{0.832} = + 77,000 \text{ lbs.}$$

$$A_5 = \frac{84,700}{0.832} = + 102,000 \text{ lbs.}$$

MINIMA.

$$A_1 = A_2 = - \frac{146,200}{0.832} = - 176,000 \text{ lbs.}$$

$$A_3 = - \frac{130,000}{0.832} = - 157,000 \text{ lbs.}$$

$$A_4 = - \frac{182,000}{0.832} = - 135,000 \text{ lbs.}$$

$$A_5 = - \frac{106,000}{0.832} = - 128,000 \text{ lbs.}$$

(To be continued.)

CORRESPONDENCE.

NATIONAL PUBLIC WORKS.

To the Committee on Publications of the FRANKLIN INSTITUTE.

GENTLEMEN:—My attention has been called to the remarks of H. W. S., in your August number, upon "The Reorganization of Public Civil Works." A different point of view is so well presented by H. in the same number, that extended comment is not required. It is easy to infer that H. W. S. may be a naval graduate, possibly of the engineering course, and that a kindred military spirit makes him more captious in regard to the civilian effort than well fits a disinterested observer. The few shrunken kernels in this peck of chaff may mislead the unwary, and therefore call for attention.

It is admitted that the Council of Engineering Societies represents the views of the civil engineering profession. No additional comment is called for.

It is possible that the scheme may sometime work as suggested by the A. B. C. illustration. Such a possibility involves a combination of two or three improbabilities, which H. W. S. is doubtless sufficient mathematician to know is a vanishing quantity. It is likely that in an organization, essentially selective in all grades, such practices will be more infrequent than under some present systems, where the clerk of the superior officer, as a technical adviser, outranks the junior personnel of the service. The illustration illustrates too much.

The publications of the Council nowhere imply that the chief of this bureau is by evolution ultimately to become the chief of a department. They expressly disclaim "an expanding organization," but advocate in time an aggregation of all the kindred bureaus. It is admitted that the chief of the bureau should be technically proficient. What the chief of the department should be is not now germane, though it may be observed that if he combines technical proficiency with executive ability, it need not be an occasion for lamentation.

The proposition to transfer one-half the Army corps to the Corps of Civil Engineers, simply recognizes that in installing the new establishment the past experience should be utilized so far as possible without impairing the military service. As the bill requires men of experience, no doubt a large proportion of the civil assistants will also enter the new establishment. This simply gives competent experience recognition beyond the mere school training of youth, and has no reference to place or manner of education.

There are sound reasons for Government education for the military service. There are sound public reasons for not extending this education to civil branches with a view to a monopoly in the civil service. This is too generally recognized for discussion. If the educational facilities outside of West Point and Annapolis are insufficient for civil requirements, doubtless they will be improved as the demand for a better article is appreciated through the civil competition of the military graduates.

The contention for the superiority of West Point education for civil pursuits has been so long abandoned that its re-assertion is decidedly refreshing. Some schools of engineering are nearly as old as West Point. The Government, in a spirit of philanthropy, has allowed graduates of the military and naval academies to go out as enlightened teachers of what it is wise to know. Surely some of these should teach as well as they have been taught, and quickly remedy the great deficiency.

Is there a presiding genius which selects for the military schools the choice brains of our land? Are there peculiar cogs in the educational machine which make them abler than able men from other schools? Are eminent educators all wrong, and the educational experience of generations at fault? Why is not the educational machine everywhere framed on these models? Is it because the admiration for the system, generically applied, is confined to the alumni of our military schools?

What constitutes an education is too large a question for present discussion. If achievements be the test, civil engineers will abide the issue. We may be sure that those who are familiar with "the quality of work done at different institutions" will never be guilty of the rash assertions of H. W. S., and he may be safely left to the tender mercy of the professors.

A provision allowing the employment of outside experts in any organization, is wise. It has happened that inventions and applications of great merit—even in arms, armament, marine engineering, etc., for the navy—have been made by men outside the ranks, and it will doubtless occur again. Such efforts are to be encouraged by provisions of law. Possibly another Eads may arise, or perhaps an Ericsson.

What the next generation may conclude is difficult to foresee. It is our duty to remedy the admitted evils of the present, and not be content on the theory that they cannot be removed because human nature is totally depraved. Experience will doubtless suggest material changes in the future, and it may be feasible still further and wisely to liberalize the service. Progress will have no debt to pay to pessimistic teachings.

What H. W. S. means to convey by comparing the pay schedule with that of "army officers of least rank allowed to do the work," is not evident. Why not compare with those of higher rank, who may do the work, if he studies the register closely, and add to their pay, fuel, forage and perquisites, and the annuity which the money invested in their education represents to the Government?

It is easy to suppose that provisions of law will be construed perversely, but is it not a fairer assumption that self-interest, if no nobler motive, will construe them in harmony with the public interests. There are possibilities and possibilities, but are they probabilities? For instance, the present service in its civil duties is without special provision of law, and we could suppose all possible evils to exist. It should be conceded that regulative provisions will not make the system of examination and promotion worse. They will certainly be needed for such a class of men as H. W. S. supposes will compose this corps.

Finally, it is admitted that improvements in the service can be made and are desirable. In all the morass of captious criticism of the Cullom-Breckinridge bill, up to this time, there has not appeared a single suggestion that could be doubled up with another, or a single body of thought outlining anything essentially different. The trouble does not seem to lie in the bill, but in mental dyspepsia occasioned by deficient digestive organs, developed perhaps on prepared food.

L. E. C.

IMPROVEMENT OF SABINE PASS.

To the Committee on Publications of the FRANKLIN INSTITUTE.

GENTLEMEN:—In the Sabine Pass controversy, Prof. Haupt finds himself unable to understand the sophistry which would object to his use of the verb to build and not to that of the Board of Engineers, which Board said that the western jetty should be *built first* and its effect observed. From my point of view the sophistry resides entirely in arguing the uses to be the same, and in stating that the work was conducted according to this view of the Board, thus laying the basis for the charge. It was not so conducted, but on my recommendation that feature was changed and work on the east jetty commenced.

In the paragraph (2) on page 141 of your August number, Prof. Haupt confounds the "shoal opposite the Clifton" with the "sand area" referred to in Mr. Raymond's report, and in the paragraph quoted therefrom in my letter at the foot of page 138 and in the paragraph at the head of page 139. They are entirely different. As this fact makes it needful that that paragraph (2) should be entirely re-written, comment upon it is impracticable. The "sand area" had the following limits: It was entirely on the outer slope of the bar; its inshore limit was in a depth of 6.5 feet almost uniformly, while its seaward edge was nearly coincident with the nine foot curve; its western end was 400 feet west of the line of the jetty and from this extremity the "sand area" extended easterly 6,500 feet. Exterior to these limits sand is not found. It thus lay upon both sides of the line of deepest water from the Pass and extended as near as may be an equal distance east and west of that line, and its width diminished as it extended eastwardly until it entirely disappeared. Sand at an earlier date was found inward of this area, upon the surface of the bar, and at the later date of the survey had disappeared therefrom and there is no sand to the eastward of this area for miles.

No one will quarrel with Prof. Haupt if he still thinks that Mr. Raymond's opinion was a dubious one and that the sand came from the eastward.

Prof. Haupt regards the deepening of three to four feet along the edges of the jetty as irrelevant when he had previously constructed a ramp over the line of one of these deepenings, up which ramp sand rolled over the jetty.

Allow me the opportunity to correct an error in my letter in the August number. Of the observations made on the jetty to determine the direction of the cross currents, there was one exception to the general rule that the direction of these currents was eastward or westward according to the direction of

the wind; this exception was found inside the "Clifton" and at a distance from the shore end of the jetty of a little more than one-fourth the distance to the "Clifton." Here, with the wind east, the current was inward across the jetty, setting nearly north—the tide falling.

Very respectfully, THOMAS TURTLE,
Captain of Engineers.

WASHINGTON, D. C., August 15, 1888.

BOOK NOTICES.

NOTES ON THE COMPRESSIVE RESISTANCE OF FREESTONE, BRICK PIERS, HYDRAULIC CEMENTS, MORTARS AND CONCRETES. By Q. A. Gillmore, Ph.D. New York: John Wiley & Sons. 1888.

The evil that men do no doubt often survives them; but that all of the good is not invariably interred with their bones, this latest work of General Gillmore bears evidence.

There is "a long felt want" which this volume (while it can hardly be said to fill it, and by no means claims to do so) at least recognizes, and does much toward satisfying. We refer to the dissatisfaction which engineers have felt with regard to the published tables of strengths of materials, based chiefly upon experiments with small specimens, carefully prepared, and tested under conditions which rarely if ever occur in practice.

While the present series of experiments can scarcely be said to give us definite and generally applicable laws for deducing the practical working strength of larger pieces from these tabular results; yet, dealing with large specimens, it renders important service, not only by confirming the suspicions which have been entertained, but by indicating some of the causes which may lead to the observed discrepancies.

As the author remarks: "It was not the intention to decide upon the relative merits of the several kinds of materials employed, but to obtain further information regarding the behavior under compressive stress of both natural and artificial stone in various gradations of size.

The experiments recorded were made with the Emery testing machine, at the Watertown Arsenal, Mass., capable of exerting a maximum pressure of 800,000 pounds, and embraced specimens of Haverstraw freestone, neat Dyckerhoff Portland cement, mortars and concretes of Newark Company's Rosendale, Norton's and National Portland cements, and piers of brickwork in Rosendale cement.

Most of the experiments were made with cubes, from one to twelve inches on a side in freestone and neat cement, and from two to sixteen inches on a side in the mortars and concretes. The brick piers were twelve inches square by sixteen inches high.

The specimens of neat cement, mortar and concrete, after being taken from the moulds, were kept buried in sand for periods varying from about two to four years or until shortly before testing.

Tests were also made of prisms of freestone and of neat cement four inches and eight inches square, and of various heights less than the sides. A dry-jointed pier of three twelve-inch cubes of freestone, and three piers of twelve-inch square slabs of neat cement were also broken.

Unfortunately (other things being equal), the larger the specimens, the smaller must be their number; and the greater the diversity of sizes the fewer tests can there be of each size. And the materials here treated of, subject as they are to unknown irregularities of structure, affecting to a great but indeterminable extent their behavior under stress, are the very ones for which a great number of experiments is particularly desirable. Hence, there is, after all, a sense of incompleteness in the results and of uncertainty in the conclusions arrived at; a defect arising unavoidably from the nature of the case, and in spite of very evident and conscientious care and industry in obtaining, observing, recording and presenting the results and in reasoning from them. This defect is freely admitted by the author in such sentences as this, which may be regarded as in some sense typical of many of the results attained:

"With respect to resilience at the elastic limit, the National Portland cement cubes are decidedly superior to those of Norton cement; but the C mortars possess somewhat more resilience than the C concretes, while with the Norton cement the reverse is the case. It is possible that if more samples had been available these relations might have been changed."

Notwithstanding this, the care taken in measuring the compressions of the specimens, by means of a caliper reading to thousandths of an inch, has enabled the author to prepare a very interesting series of diagrams, which, while of course presenting different forms for the several materials operated upon, show for a given material a uniformity hardly to be expected in view of the irregularities of structure already referred to.

In addition to the results referring especially to the several materials tested, the following conclusions of general interest were reached:

From previous experiments upon cubes of Berea stone measuring from one-quarter inch to four inches on a side, the author had constructed the following formula for the strength of cubes of different sizes and of a given material:

$$\left. \begin{array}{l} \text{Breaking load of a given cube} \\ \text{in pounds per square inch} \end{array} \right\} = \frac{\text{Breaking load of a}}{1 \text{ inch cube in pounds}} \times \left(\frac{\text{Edge of given}}{\text{cube in inches}} \right)^{0.333}$$

The more recent experiments here described failed to confirm the formula, the larger cubes generally giving way under less loads than it would have required. This failure is quite plausibly explained as being probably due to greater want of homogeneity in the larger specimens as compared with the smaller cubes, in which "the soundest pieces are necessarily selected," whereas "the difficulty of close examination and proper selection, and the probability that the specimen contains unsound parts, increase with the size of the cubes." It is quite possible, as the author suggests, "that the law, perhaps more or less modified, would be corroborated if it were possible to provide a series of varying sizes, each of which was truly homogeneous throughout." But, even so, the impossibility of securing such homogeneity

in practice, deprives the formula of utility as a working rule, and renders it simply an interesting scientific discovery, at least until we learn to make useful practical deductions from it. But the experiments are valuable as showing the danger of applying to stone of working sizes the published figures based generally upon experiments with small specimens, for these last were found to sustain generally a very much greater pressure than the larger cubes. A comprehensive series of tests upon the crushing strengths of materials in large masses would go a long way toward reducing the "factor of ignorance," which must in the meantime be employed.

The experiments upon prisms of freestone and of neat cement shorter than a cube, showed unmistakably a considerable increase of strength with decrease of length, the area of bed surface remaining the same. A formula is given, designed to express the strengths of such prisms in terms of the strength of a cube having the same bed surface area, and of the average strength per square inch of the material, as obtained from experiments on cubes. It agrees with the results of experiments upon such slabs perhaps as well as could be expected from such material; but its rather complicated form and its limited applicability would seem to forbid it a great measure of practical utility.

In crushed specimens of freestone, the principal fragments, as has been noted in other experiments upon similar materials, generally consisted of one or two irregular pyramids, more or less fully developed, with the bed-faces, or rather the larger portion of the same, as bases.

Eight freestone cubes, with bed-faces carefully smoothed and then coated with a thin film of plaster of Paris, developed generally greater and more uniform strength than similar cubes without the plaster.

Stone blocks, when arranged or built up in courses, have less strength than the individual pieces, but no attempt is made to deduce a law covering such cases.

The absolute resilience of cubes of freestone and of kindred material appears to be approximately proportional to the mass of the cube. The only serious deviation from this appears in certain of the largest (sixteen-inch) cubes of mortar and concrete; and may perhaps be readily explained away in view of the difficulty of securing perfectly similar manipulation and equal and uniform setting in such large specimens.

The resilience of stone pillars, loaded across their entire cross-section, seems to increase as their height increases, while their capacity to resist dead loads decreases.

From earlier experiments it had appeared that specimens of stone, etc. (and especially the stronger ones), were materially weakened by the interposition of wooden cushion-plates between the pressed surfaces of the specimen and the pressure plates of the testing machine, the wood spreading laterally in crushing, and thus exerting a lateral tearing force upon the specimen. This was confirmed by the present experiments upon concrete cubes. "Those crushed directly between the machine heads proved in

every instance stronger than their mates, which were broken between wooden cushions."

Under considerable pressures, the concrete specimens compressed much more rapidly than neat cements or freestone.

Concretes are generally stronger and have greater resilience than the mortars from which they are made; but (which seems contradictory) those mortars and concretes proved strongest and most resilient which were richest in cement. No doubt a more extensive series of tests might show a certain proportion of cement as giving the maximum strength, the strength falling off as this proportion was either increased or diminished.

The *quality* of the cement is of even greater importance than its *quantity*. Mortars and concretes of "National Portland cement are fully three times as strong as the Norton mortars," the specimens being identical in all other respects, although "Norton's cement enjoys a good reputation in the market."

The breaking of a sixteen-inch cube of concrete made from National Portland cement by means of five applications of the maximum load of the machine (800,000 pounds), after it had resisted its first four applications, suggested the importance of extending to such materials as brick, stone, concrete, etc., experiments upon the fatigue of materials, similar in principle to those made upon metals by Wöhler, Spangenberg and Bauschinger.

The six brick piers tested were built up of common hard North River brick with three-eighths inch joints of mortar of one part Newark Company's Rosendale cement and two parts sand. Each pier had a base and cap of North River bluestone, of the same cross section as the pier, and with bed-faces rubbed smooth and plane. The piers were one year nine and a half months old when broken. Their crushing strength varied between 250,000 and 291,000 pounds total, average 266,587 pounds, equivalent to 1,851 pounds per square inch, or 119 gross tons per square foot. This is rather high as compared with the figures generally published for such columns, which, however, are probably based mostly upon work of less age.

The importance of a wider knowledge as to the resilience or blow-resisting qualities of building stones, mortars, masonry, etc., is pointed out. While the present work undoubtedly constitutes, as the author very modestly believes, "a contribution of some value" in this respect, it must yet be regarded as scarcely more than a first step; for with the exception of one or two broad generalizations noted above, its data are chiefly of value in connection with the very few materials experimented with.

T.

THE FUNDAMENTAL PRINCIPLES OF CHEMISTRY. By Robert Galloway. London: Longmans, Green & Co., 1888. (J. B. Lippincott Company, Philadelphia. Price, \$1.75.)

The title of this work is hardly a correct index of its contents. Of the fifteen chapters into which the book is divided seven treat entirely of the physical properties of matter, the remaining eight being devoted to the principles of chemistry. As there are but about 350 pages, it follows that the latter half—that on chemistry—must necessarily be very condensed and

incomplete. Even this latter half, however, is not satisfactory, for while it is true that the author's idea is to give a description of the principles of the science rather than a list of the *properties* of the different elements, it is difficult to see why the latter should appear at all. And this is all the more true, when we remember how little space there is for the more important theoretical portion—that relating to the “Fundamental Principles.” The logical result of this treatment of the subject is that when he comes to the properties of the elements, he may almost be said to give a description in which nothing is described. For example:

Boracic Anhydride.—This compound is prepared by heating the acid to redness; it is a colorless, transparent, vitreous solid.

The value of such a statement, to the student, is simply *nil*, especially when not a solitary word is given of further description.

But the most extraordinary part of the book is the introduction of such a large quantity of matter on physics, in a work which treats of chemistry. Seven pages are given to the description of the air pump; eight to the thermometer. “Capillary Action,” makes up the bulk of Chapter VII, “Specific Gravity,” the entirety of Chapter V. In some struggling provincial college, where one professor has to teach all the sciences, this jumbling of one with the other might be accepted as the shortest way of covering the greatest space. But how Prof. Galloway could select such a plan as the basis of a new treatise on chemistry, is, indeed, a puzzle. He states in the preface that he is confident that the plan of the book is “more in harmony with the laws of thought than the chemical text-books that are in use in schools, and for teaching junior students generally.” But when we remember how many excellent treatises there are on physics and on chemistry, for either the lecture or the laboratory, we are much afraid that the author's confidence, as above expressed, is misplaced.

H. P., JR.

THE CHRONICLE FIRE TABLES FOR 1888. A Record of the Fire Losses in the United States by States, Risks and Causes during 1887, with Exhibits of the monthly, annual and aggregate Fire Losses in the United States during Thirteen Years (1875-1887) and much other valuable information for Fire Underwriters. New York, 1888. Published by the Chronicle Company, Limited. Price, \$5.

This invaluable compilation of fire statistics has now reached the fifth volume, having been much enlarged in 1885, and has become indispensable to fire insurance offices and insurance brokers. To many other parties it is advantageous, especially the statistician, historian and political economist. The fires and resulting property losses and insurance losses, are tabulated and grouped by States and Territories, giving clearness and facility of reference. The general student also will find a great mass of valuable information condensed in this volume. There are five diagrams, showing comparative fire losses in the United States during 1887, from known causes; movement of the fire loss for thirteen years; relation of fires to failures; monthly curves of incendiary fires for five years; dwelling-house fires by principal causes, etc.

There are four charts showing geographical distribution of incendiarism

in the United States during 1884, '85, '86 and '87. A large colored frontispiece depicts, in proportionate size of space and amounts in dollars, the fire losses from exposure, incendiarism, defective flues, spontaneous combustion, lightning, explosions, sparks, friction of machinery, matches, engines and boilers, forest and prairie fires, locomotive sparks and sixteen minor causes. These and the detailed tables, show the losses from *known* causes, including exposure, were \$53,471,020 in 1887, while the grand total of fire losses for the year was \$119,209,380. Finally, at page 125, is a colored diagram with the comparative number of dwelling-house fires in the United States, in 1887, by thirty-six principal causes delineated in relative size, from greatest to least; the proportions and data based on an examination of 32,801 fires in dwellings and tenements.

No other record like this volume is published, the nearest approximation being one annual State fire table and the fire patrol reports of our principal cities. The Chronicle Fire Tables can properly be called one of the most valuable statistical annuals ever attempted in any country; and its value increases with every year of its publication. N.

THE HISTORY OF INSURANCE IN PHILADELPHIA FOR TWO CENTURIES, 1683-1882. By J. A. Fowler. Philadelphia: Review Publishing and Printing Company, 1888. Royal 8vo. 910 pages. Price, \$10.

This work, just issued from the press of the Review Publishing and Printing Company, is remarkable and elaborate. Its merits and scope are so great, that it is difficult to know where to commence their enumeration or where to end. In an introduction, the most ancient forms of insurance are given, illustrated by the text and translation of an Italian marine insurance policy of 1385, and a Latin life policy of 1427. These are certainly earlier than any policies as yet published in the United States. The introduction also shows how the insurance idea gradually developed into an important business.

Coming to the years when Pennsylvania and Philadelphia were founded, the author treats largely of the personal Philadelphia and English marine underwriters, showing also, how deferred and survivorship annuities were computed in Boston in 1732, and term fire risks first taken on buildings in Philadelphia by the company, called the "Contributionship," instituted in 1752. Then follow from 1759 to 1825: Life Insurance as Deferred Annuities, 1752-1800; Lottery Ticket Insurance, 1761-1771; Personal Philadelphia Marine Underwriters, 1776-1815; Associated Marine Underwriting, 1792-1803; Corporate Marine Insurance, 1794-1882; Ransom Insurance, 1794-1803; Fire Insurance Upon Personal Property, 1794-1882; Perpetual Fire Insurance on Buildings; General Life Annuities, 1813-1882; Term Contingency and Endowment Life Insurance, 1813-1882; also, Inland Navigation Risks.

The following, besides numerous collateral subjects, are then taken up *seriatim*, each accompanied by data, and most of them by illustrative examples and judicial decisions, to such extent, that the amount of information

furnished is almost bewildering, viz: Health Insurance, 1848-1857; Deposit Life Insurance, 1850-1851; Live Stock Insurance, 1850; Slave Insurance by Philadelphia Companies in Southern States, 1852-1861; The Era of Fraud, 1850-1875; Storm Insurance, 1857; Accident Insurance, 1864-1882; Rent and Leasehold Insurance, 1865-1882; Plate Glass Insurance, 1867-1882; Steam-Boiler Inspection and Insurance, 1868-1882; Industrial Life Insurance, 1879-1882; Fidelity Insurance, 1881-1882.

In the extensive and elaborate researches to obtain data of companies and references to them and their business, in the period 1801-1882, there has been brought to light an amount of information which surprised the historian, and must naturally give more astonishment to his readers. With consummate skill all these facts and figures have been sifted, adapted and interwoven into history, while the various kinds of insurance originating in Philadelphia are fully described, in the rise, flourishing and decay of companies, whose names, date of institution, business and data therewith connected are furnished. There are also many examples given to prove doctrines and formulæ; and a number of reproductions of important policies and other instruments of insurance occur. There must have been an enormous amount of labor and much expense in the collection of all this information, especially the older data; and some of it has evidently been obtained from obsolete and almost unknown sources.

The work is divided into:

PART I.—Marine insurance, marine-fire insurance, fire-marine insurance and insurance in general—where the *main* subjects elaborated (besides many others) number over fifty.

PART II.—Fire Insurance, ditto, eighty *main* subjects.

PART III.—Life Insurance, ditto, seventy-five *main* subjects.

PART IV.—Miscellaneous Insurances, ditto, forty *main* subjects.

The particulars, exemplifications, proofs and data of all these (besides numerous other subjects not here enumerated), though concisely given, make up a vast mass of information, such as rarely has been condensed by one writer into a single large volume. This history is followed by an analytical and topical index, in four parts, corresponding with those above mentioned, comprising nearly 2,800 titles and 4,400 page references.

A conspicuous feature of this exhaustive work is the great attention given to the manufacturing risks of Philadelphia in their inception, progress and development, together with their technological relations to insurance. This story of growth, from small to vast proportions, accompanied by very varying and sometimes wholly disproportionate insurance premiums, is a story such as was never before written of any city or of any country. Philadelphia being the greatest manufacturing city of the United States (probably, indeed, of the world), and as the development of its manufactures, besides aiding fire insurance, contributed to the exportations of the city and increased marine insurance (also indirectly influencing life and miscellaneous insurance), there seems especial fitness in the minute attention paid to this important part of the insurance and manufacturing development of the city.

The technical exactness with which each relation of such risks is traced to its source, its development followed and illustrative calculations and tables made, based on such facts, shows the extraordinary technical and analytical ability of Dr. Fowler as an insurance expert, and as historian of a subject so difficult, even to superior writers in this specialty. As the formation of this history occupied all the time its author could spare from his editorial duties for nearly five years, so it will require the remaining lifetime of the average insurance man to master its contents. Such fact, however, need not prove alarming, for this volume is destined to be one of the standard works of the world, referred to in all time; by which we mean that it will be found needful to all persons and professions having relations with insurance; and the political and social economist will find it indispensable to his studies.

To the general reader, perhaps, the most special interest of this book will be its character as a history of the city of Philadelphia. It may properly be regarded as the most successful attempt ever made to present the record and details of the economic development of a locality. In such respect this production may be pronounced wonderful, and as a history of the city of Philadelphia merely, is the greatest that has yet been written. It is doubtful whether any other metropolis can present an equally explicit and instructive narrative.

In relation to this, his masterpiece, Dr. Fowler, might well predict, as Horace did of his own productions :

Exegi monumentum ære perennius,
Regalisque situ pyramidium altius;
Quod non imber edax, non Aquilo impotens
Possit diruere, aut innumerabilis
Annorum series, et fuga temporum !

LEITFADEN FÜR DEN UNTERRICHT IM SCHIFFBAU. Von A. van Hüllen, Kiel und Leipzig : Lipsius & Tischer.

This work, the author of which is chief engineer in the German Navy and instructor at the Naval Academy at Kiel, Germany, is principally intended for use at such institutions, hence more attention is paid to war vessels than to those for mercantile purposes, and considerable space is devoted to construction of wooden vessels, which, although on the decline for merchant service, are still of some importance for naval purposes.

The chief merit of the work is the minuteness with which all operations in ship construction are described, from the first plan, the laying down on the mold loft, the building ways, the details of the structure, etc., until the final completion, launching and equipment,

Comparing wood and iron ships, their respective elements of strength, under different conditions, are very clearly stated. The chapters devoted to the conservations of vessels by painting, cementing, etc., are also interesting, while those on water-tight bulkheads and drainage arrangements are fully up to the latest improvements in modern war vessels.

The chapter on armor is profusely illustrated with the latest varieties of armored vessels, and details of armor construction. Chapters on rudder and steering apparatus, on spars and boats conclude the practical part of the

work, the remainder being devoted to hydrostatics of ship construction, tonnage measurement, stability, the action of sails, resistance of vessels and other scientific matters relating to naval architecture. This part, while treated with great thoroughness, is yet simpler than most works on this subject, being almost entirely free from higher mathematics, a consideration of importance to those, who, after years of practice in the engineering profession, have become somewhat rusty in the integral and differential calculus. J. H.

THE ASHCROFT MANUFACTURING COMPANY'S IMPROVED TAPOR INDICATOR.

In this improved instrument, the arrangement of the parallel motion mechanism is reversed, by which means a range of motion of the pencil of 3.25 inches is obtained. The curved slot by which the pencil is made to move in a straight line is transferred from the piston rod to a stationary guide, firmly secured to the cover of the cylinder. In the new instrument the roller is the moving part, whereas in the old instrument it was stationary. By the above changes the parallel motion multiplies the piston movement five times.

The treatise accompanying the instrument is designed for reference and contains instructions for purchasers and others interested in the subject.

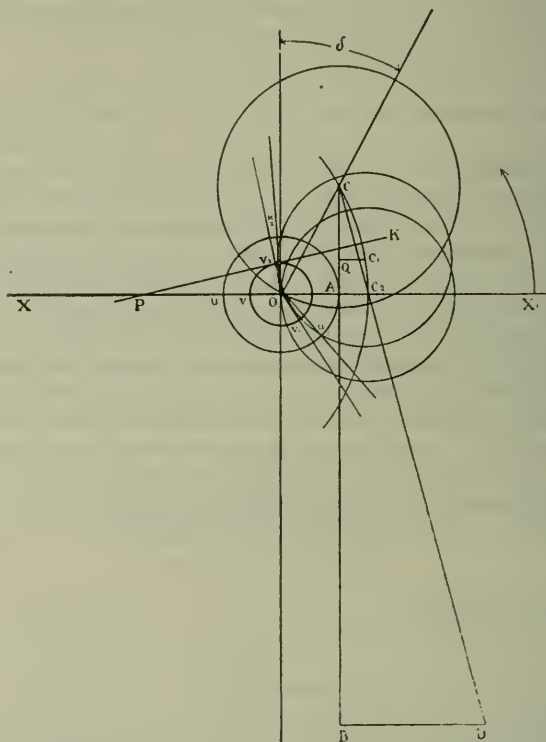
Mr. Barrus' directions respecting the manner in which the improved instrument should be used are exceedingly clear and concise, and are of a thoroughly practical character, giving full instructions as to the best methods of securing the instrument, giving motion to the paper, etc., and, in fact, including everything which it is necessary to say upon the subject. LE VAN.

SCIENTIFIC NOTES AND COMMENTS.

TECHNOLOGY.

THE ZEUNER VALVE DIAGRAM. John L. Gow, Assistant Engineer, U. S. N.—In the application of the Zeuner diagram to valves fitted with link motions giving unequal leads for different positions of the link, the use of the graphical method of solution becomes more complicated from the fact that the centre of the valve circle moves in the arc of a parabola as the link is raised or lowered. That is, in the figure if C , C_1 , C_2 , are the centres of valve circles corresponding to three different positions of a Stephenson's link, then the curve $C C_1 C_2$ is a parabola. A circle whose centre is on the line AX_1 and passing through the points C and C_2 , will be found to practically coincide with the part of the parabola used in the diagram. To draw this circle the following method is given. In the figure suppose C to be the centre of the valve circle when the link is in full throw. From C draw the line CB at right angles to OX_1 , and make CB equal to the length of the eccentric rod. At B draw a line parallel to OX_1 , and lay off a distance BD equal to the half length of the link, to the right if the rods are open and to the left if crossed. Join C and D and the point C_2 where CD crosses OX_1 , is a second point in the

circle. Bisect $C C_2$ by the perpendicular $P K$ and the point P where this line cuts $O X$ is the centre of the circle and $P C_2$ is the radius. Suppose it is desired to determine the distribution of the steam if the link is one-third the way down. Mark the point Q so that $A Q = \frac{1}{3} A C$. Draw $Q C_1$ parallel to



$O X_1$, and take the point C_1 where it cuts the circle as the centre of the valve circle and $C_1 O$ as a radius. If $O U$ is the steam lap and $O V$ the exhaust lap, the steam port opens when the crank gets to $O U_1$, and closes at $O U_2$ and the exhaust port opens at $O V_1$, and closes at $O V_2$.

The travel of the valve as given by Zeuner, third edition, p. 63, for Stephenson's link with open rods, omitting the last term is

$$r \left(\sin \delta + \frac{c^2 - u^2}{c l} \cos \delta \right) \cos \omega + \frac{u r}{c} \cos \delta \sin \omega$$

in which r is the half travel of the valve, δ is the angle of advance, c the half length of the link, u the distance the link has moved from its central point, l the length of the eccentric rod, and ω is the amount the crank has moved from the dead point. For different positions of the link, or different values

of u , the centre of the valve circle is at the points whose co-ordinates are

$$\frac{r}{2} \left(\sin \delta + \frac{c^2 - u^2}{c l} \cos \delta \right)$$

and

$$\frac{u r}{2 c} \cos \delta$$

If the link is in full throw then $u = c$ and the co-ordinates become

$$O A = \frac{r}{2} \sin \delta$$

and

$$A C = \frac{r}{2} \cos \delta$$

The point C is usually determined graphically in using the diagram. If $u = 0$ or the link is in mid-position then the co-ordinates become

$$\frac{r}{2} \left(\sin \delta + \frac{c}{l} \cos \delta \right) = O C_2 \text{ and } o$$

To prove that our construction makes

$$O C_2 = \frac{r}{2} \left(\sin \delta + \frac{c}{l} \cos \delta \right)$$

we have

$$O C_2 = O A + A C_2$$

But

$$O A = \frac{r}{2} \sin \delta$$

and from the figure

$$\frac{A C_2}{A C} = \frac{c}{l}$$

or

$$A C_2 = A C \times \frac{c}{l}$$

But

$$A C = \frac{r}{2} \cos \delta \therefore A C_2 = \frac{r}{2} \cdot \frac{c}{l} \cos \delta$$

and

$$O C_2 = \frac{r}{2} \left(\sin \delta + \frac{c}{l} \cos \delta \right)$$

as before.

As we have never seen an easy method by which the influence of the link could be graphically laid down, it is believed that the method above given will allow the entire distribution of steam to be investigated without any other work than can be done on a drawing board.

H. W. S.

TO DETERMINE THE SIZES OF CYLINDERS FOR SUCCESSIVE EXPANSION ENGINES. John L. Gow, Assistant Engineer, U. S. N.—Assume that Fig. 1 represents the combined theoretical cards for an engine having n cylinders. Let V_1 be the volume of the high pressure cylinder to the point of cut-off;



FIG. 1.

V_1 , the total volume of the first cylinder; V_2 , that of the second; . . . V_n , that of the last or low pressure cylinder. Let P_1 be the initial absolute pressure and P_n the final back pressure. Assume that the law of the expansion is $PV =$ a constant, and that the expansion in the n th cylinder is carried on to the back pressure line. If r is the total number of expansions then

$$r = \frac{P_1}{P_n}.$$

The area of the entire card will then be

$$A = P_1 V_1 (1 - \log_e r) - P_n V_n = P_1 V_1 \log_e r. \quad (1)$$

Below the line a the area of the card is

$$\frac{n-1}{n} A = P_1 V_1 \left(1 - \log_e \left\{ \frac{V_n}{V_1} \right\} \right) - P_n V_n = P_1 V_1 \log_e \left\{ \frac{V_n}{V_1} \right\}$$

and below any line as the d th the area is

$$\frac{n-d}{n} A = P_d V_d \left(1 + \log_e \left\{ \frac{V_n}{V_d} \right\} \right) - P_n V_n = P_d V_d \log_e \left\{ \frac{V_n}{V_d} \right\}$$

or

$$A = \frac{n}{n-d} P_d V_d \log_e \left\{ \frac{V_n}{V_d} \right\} \quad (2)$$

and combining (1) and (2) we have

$$\frac{n-d}{n} P_d V_d \log_e \left\{ \frac{V_n}{V_d} \right\} = P_1 V_1 \log_e r$$

or, as $P_1 V_1 = P_d V_d$,

$$\frac{n}{n-d} \log^r \left\{ \frac{V_n}{V_d} \right\} = \log^r r.$$

$$r = \left\{ \frac{V_n}{V_d} \right\}^{\frac{n}{n-d}}$$

or

$$V_d = \frac{V_n}{r^{\frac{n}{n-d}}} \quad (3)$$

To apply this formula to a triple expansion engine $n = 3$, and making $d = 1$ and 2, we have for the horse-power cylinder

$$V_1 = \frac{V_3}{r^{\frac{2}{3}}}$$

and for the intermediate cylinder

$$V_2 = \frac{V_3}{r^{\frac{1}{3}}}.$$

For a quadruple expansion engine the cylinders would be

$$\frac{V_4}{r^{\frac{3}{4}}}, \frac{V_4}{r^{\frac{1}{2}}}, \frac{V_4}{r^{\frac{1}{4}}}, \text{ and } V_4.$$

Equation (3) can be put into a more convenient form by putting

$$\frac{\pi D^2 L}{4} \text{ for } V$$

D being the diameter of the cylinder and L the stroke. The formula then becomes

$$D_d = \frac{D_n}{r^{\frac{n}{n-d}}}$$

or the diameter of any cylinder can be formed directly from the ratio of expansion and the diameter of the low pressure cylinder. An application of this formula to many of the triple and quadruple expansion engines lately built will show that the dimensions obtained from the formulæ agree very well with recent practice.

The following are some of the latest quadruple engines built:

	<i>H. P.</i>	<i>L. P.</i>	<i>Second.</i>	<i>Third.</i>	<i>Calculated</i>	
					<i>Second.</i>	<i>Third.</i>
County of York, ...	20	57	28½	—40	28·34	40·2
Grace Darling, ...	10	28	14	20	14·09	17·86
Myrth, ...	12	14	17	24	16·08	24·02
City of Venice, ...	30	70	40	52	30·78	52·77
Buenos Ayres, ...	12	92	46½	64½	45·50	64·80
Suez, ...	22	62	30	41	31·11	41·89

H. W. S.

CHEMISTRY.

ON THE PREPARATION OF PURE HYDROGEN IODIDE.—Lothar Meyer (*Berl. Ber.*, **20**, 3,381). The author finds that the phosphonium compounds usually present in hydriodic acid are owing to the use of an excess of phosphorus in the preparation. The formation of such compounds may be avoided by operating in the following manner: 100 grammes of iodine are introduced into a tubulated retort, whose neck is inclined upwards, and moistened with ten grammes of water. To the tubulure of the retort is adapted a funnel, the extremity of whose opening is closed by a glass rod, ground in. In the funnel is placed a mixture of five grammes of amorphous phosphorus and ten grammes of water, and when the apparatus is ready a *single drop* of this mixture is allowed to fall into the retort. If more than a single drop be added the reaction becomes exceedingly violent and terminates in an explosion. When the reaction of the first drop is apparently complete, another drop is added, and in a short time the addition may be made more rapidly; a quarter of an hour is required for the quantities named. No heat is necessary for the evolution of the gas, but at the close of the operation a gentle heat may be applied, and the iodine that has been carried over by the hydrogen iodide and deposited in the neck of the retort, is washed back by the condensed vapor. If it is desired to obtain all the acid as the product of one operation, the neck of the retort is now inclined downwards, and the liquid distilled; any unaltered phosphorus present should first be removed from the liquid by filtration. The residue is syrupy, colorless phosphoric acid.

W. H. G.

UTILIZATION OF PETROLEUM "SLUDGE ACID."—W. P. Thompson (*Journal of the Soc. Chem. Industry*, 1888, p. 353) gives some account of Rave's process for obtaining valuable products from this waste material. The tarry acid is kneaded with iron borings or filings, copper or zinc or other metallic cuttings, the material preferred being iron cuttings or borings. After more or less prolonged contact, depending upon the nature of the metal and its degree of fineness, the sulphuric acid will be found to have combined with the metallic base. The mass is now introduced into heated receptacles and boiling water is added. The metallic sulphate dissolves and separates from the black mass and the latter melts and rises to the surface. It is withdrawn from the receptacle, and is found to have all the mechanical properties of the best purified soft bitumen. It is well washed with hot water to remove all traces of salts and the wash waters used to dissolve out fresh quantities of salts in a succeeding operation. Any uncombined metal falls to the bottom. The watery solution containing the metallic sulphate and other salts is drawn off into crystallizing reservoirs.

The black mass, or bitumen, being too soft for many purposes, is placed in a still and heated until it assumes the required degree of hardness. The hydrocarbons given off in this operation are collected and used as naphtha. The resulting bitumen is very pure and can be used for almost all purposes for which the purest native bitumens are used, while at the same time it is so elastic and malleable as to strongly resemble india-rubber; hence it is largely sold by the Société Oleo-graisse, who work the Rave process under the name

of "mineral caoutchouc-bitumen." One ton of acid tar produces about ten hundredweight of this purified bitumen. If the distillation of the soft bitumen be carried farther, a material soluble in naphtha but nearly as hard and tough as ebonite is obtained. This is an extremely good non-conductor of electricity, is unacted upon by acids or alkalies, and is therefore adapted for making galvanic batteries, for coating acid tanks, conducting wires and cables, for insulation plates and the like. It can be made of all degrees of hardness and moulded by heat, either pure or admixed with fibrous and strengthening materials.

If the mineral caoutchouc-bitumen be mixed with about forty per cent. of sawdust and a little lime, heated in an iron vessel and pressed into moulds, it makes an admirable fuel, burning well in a fireplace without melting and with little ash.

The "mineral caoutchouc-bitumen" dissolves readily in petroleum, naphtha and other light hydrocarbons, and forms an excellent tough, black varnish. This varnish is water-proof and adheres very tightly to metal, not chipping or scratching off so easily as Brunswick black or Japan varnish. The bitumen also forms compounds with rosin, wax, pitch and other like materials, with qualities intermediate between those of their constituents.

To sum up, at the expense of the requisite quantity of iron cuttings or oxide, the entire sulphuric acid in the material is obtained as green vitriol. One-half the weight of the original acid tar is utilized as soft bitumen, or this is still further differentiated by distillation and this fifty per cent. is converted into seventeen per cent. light naphtha and burning oils; eight per cent. heavy lubricating oils, and twenty-five per cent. metallic carbon.

S. P.

RECOVERY OF SULPHUR FROM ALKALI WASTE BY MEANS OF LIME-KILN GASES.—What seems to be a fundamental improvement of the well-known Leblanc Soda process has just been announced by Mr. Alexander M. Chance (*Jour. Soc. Chem. Indust.*, 1888, p. 162). The process claims to recover, either in the form of brimstone or as sulphuric acid, ninety-five per cent. of the sulphur previously wasted in the calcium sulphide of the Leblanc method, and as the quantity of pyrites used exclusively for making soda by the Leblanc process, the sulphur of which is now thrown away, is estimated at about 300,000 tons a year, it will be seen that the success of the new process means almost a commercial revolution. The process is based upon certain patents issued in 1882 to C. F. Claus for recovering sulphur from the sulphuretted hydrogen of coal gas. Carbonic acid diluted with nitrogen, as given off from the lime-kiln, is used to decompose the calcium sulphide or alkali waste, and liberate hydrogen sulphide in a regular stream. This gas, mixed with a proper amount of air, is passed over heated oxide of iron or other contact substances, whereby it is burned according to the reaction $2 \text{H}_2\text{S} + \text{O}_2 = 2 \text{H}_2\text{O} + \text{S}_2$. The oxide of iron is maintained by the heat of the reaction at a dull red heat and undergoes no change, while free sulphur accompanied by vapor of water passes off. The free sulphur is obtained in the fused or sublimed form according to the temperature of the kiln and of the depositing

chambers. Or, by burning the sulphuretted hydrogen as liberated, the whole of the sulphur may be utilized in the sulphuric acid manufacture, the heat of the burning gas being sufficient to work the Glover tower. Of great importance is the ingenious method of getting rid of a considerable quantity of the diluting nitrogen before attempting to burn the sulphuretted hydrogen gas. This is done by passing the H_2S and nitrogen liberated by the lime-kiln gases from one portion of waste into another vessel with a further quantity of waste which absorbs the H_2S to form $Ca(HS)_2$, leaving the nitrogen gas on unabsorbed. The carbon dioxide attacking this liberates a double quantity of H_2S according to the reaction, $CO_2 + Ca(HS)_2 + H_2O = CaCO_3 + 2H_2S$. The gas is now sufficiently rich in H_2S to burn as before represented. The sulphuric acid produced by this process is extremely pure, being quite free from arsenic, contains a mere trace of iron and is almost colorless. Very interesting statements as to the cost of the process and the great saving effected by its use are given and illustrations of the necessary apparatus.

S. P. S.

THE SUPPOSED IDENTITY OF RUTIN AND QUERCITRIN.—E. Schunk. (*Proc. Chem. Soc.*, **17.**) 1887-88. The author employed a sample of quercitrin, made by himself from quercitron bark, and it was found to have the composition and properties assigned it by Liebermann and Hamburger. The rutin was prepared from buckwheat leaves.

A comparative examination of the two substances led to the conclusion that they differ essentially as regards composition, but that they are still extremely similar.

Rutin yields with acids the same products of decomposition as quercitrin, viz: quercetin and iso-dulcite, but not in the same relative proportion; it gives less quercetin and more iso-dulcite.

The analyses of rutin agree with the formula $C_{42}H_{50}O_{25}$, that of quercitrin being $C_{36}H_{38}O_{20}$. The process of decomposition by acids would be represented by the equation:



Hence it would appear that rutin is derived from one molecule of quercetin and three molecules of iso-dulcite, and quercitrin from only two molecules of the latter and one of the former.

H. T.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Alumni Association of the Philadelphia College of Pharmacy. Twenty-fourth Annual Report. From the Association.

Association Française pour l'Avancement des Sciences. 15e session. 1886. From the Association.

Baltimore College of Dental Surgery. Forty-ninth Annual Catalogue. From the College.

Bibliothèques et des Archives. Annuaire pour 1888. From the Minister of Public Instruction.

- Board of Public Education. Sixty-eighth and Sixty-ninth Annual Reports.
From the Board.
- Boston Public Library. Bulletin No. 77. From the Library.
- Bureau of Statistics of Labor. New York. Fifth Annual Report.
From Hon. C. F. Peck, Commissioner.
- Central Pacific Railroad. Statement of Leland Stanford.
From the Central Pacific Railroad Company.
- Department of Agriculture, U. S. Division of Entomology. Periodical
Bulletin. No. 1, Vol. 1. Division of Pomology. Bulletin No. 1. Re-
port of the Statistician. No. 53. From the Department.
- Department of State. Papers relating to the Foreign Relations of the United
States for 1887. Reports of the Consuls of the United States. Nos. 91
and 92. From the Department.
- Engine, Boiler and Employer's Liability Insurance Company. Chief Engi-
neer's Report for 1887. From the Chief Engineer.
- Engineers' Society of Western Pennsylvania. Charter, By-Laws and List of
Members. From the Society.
- Fairmount Park Art Association. Unveiling of the Equestrian Statue of Major-
General James Gordon Meade, October, 1887. From the Association.
- Fischer-Treuenfeld, R. v. Feldtelegraphie. From the Author.
- Geological and Natural History Survey of Canada. Annual Report for 1886.
From the Director.
- Hale, P. M. In the Coal and Iron Counties of North Carolina, 1883.
The Woods and Timbers of North Carolina, 1883.
- Hand-book of North Carolina, 1886.
From the Department of Agriculture, N. C.
- Harvard College Observatory. Annals. Vol. 18. Nos. 3-5.
Second Annual Report of the Photographic
Study of Stellar Spectra. 1888
From Prof. E. C. Pickering, Director.
- Illinois State Laboratory of Natural History. Vol. 3. Article 4.
From the Laboratory.
- Indiana Society of Civil Engineers and Surveyors. Proceedings of the
Eighth Annual Meeting. From the Society.
- Institution of Civil Engineers. London. Minute of Proceedings. Vol. 93
From the Institution.
- Kansas Crop and Weather Bulletin for the Month ending June 30, 1888.
From the State Board of Agriculture.
- Lanza, G. Heating Passenger Cars by Steam from the Locomotive
From the Author
- League Island. Advantages of, for a Naval Station. 1866.
From Mr. Lorn Blodget.
- Massachusetts State Agricultural Experiment Station. Bulletin No. 30.
From the Station
- Mercantile Library of New York. Finding List of French Fiction.
From the Library

- Meteorological Department of the Government of India. Cyclone Memoirs.
Part 1. From the Department.
- Minerals and Mineral Localities of North Carolina. 1888.
From the Department of Agriculture.
- Museo Nacional de Rio de Janeiro. Archivos. Vol. 7. From the Museum.
- Newark, N. J. Report of the Board of Health for 1887. From the Board.
- New Jersey. First and Second Reports of the Dairy Commissioner.
From the Commissioner.
- New York State Museum of Natural Bulletin Nos. 2 and 3.
From the Museum.
- New York State Pharmaceutical Association. Proceedings of the Tenth
Annual Meeting. From the Association.
- North Carolina Geological Report. By E. Emmons. 1858.
From the State Librarian.
- Ores of North Carolina. 1888. From the Department of Agriculture.
- Pennsylvania Hospital. Report of the Board of Managers. 1887.
From the Secretary of the Board.
- Pennsylvania Museum and School of Industrial Art. Announcement.
From the Museum.
- Pennsylvania State College Agricultural Experiment Station. Bulletin No. 4.
From the Station.
- Philadelphia in 1888. Map. From Messrs. Burk & McFetridge.
- Royal Cornwall Polytechnic Society. Fifty-fifth Annual Report.
From the Society.
- Smithsonian Report, 1885. Part 2. From the Smithsonian Institution.
- State Agricultural College, Colorado. Ninth Annual Register.
From the College.
- Summer Homes on the Picturesque Erie. From Mr. F. L. Herrick.
- Tebbutt, J. History and Description of Mr. Tebbutt's Observatory. 1887.
From the Author.
- Technical School of Cincinnati. First Annual Catalogue. Addresses at
Closing Exercises. 1888. From Mr. G. R. Carothers.
- Technikum Mittweida Programm. Bericht über das 18te bis 21te Schuljahr.
From the Institute.
- Trautwine, J. C. Civil Engineer's Pocket-Book.
From Mr. J. C. Trautwine, Jr.
- United States Coast and Geodetic Survey. Appendix No. 12. Report for
1886. From the Survey.
- Ward, T. H. International Copyright in Works of Art.
From the Author.
- Wisconsin State Historical Society. Collections. Vol. XI.
From the Society.
- Women's Silk Culture Association. Eighth Annual Report.
From the Association.
- Yale University. Report for 1886-7 and 1887-8 of the Observatory.
From the Managers.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI.

OCTOBER, 1888.

No. 4.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

AN INQUIRY INTO THE RELATIVE VALUE OF ALUMINIUM AND ITS ALLOYS TO THE ARTS.

BY H. PEMBERTON, JR.

[*Read at the Stated Meeting of the FRANKLIN INSTITUTE, Wednesday,
September 19, 1888.*]

JOS. M. WILSON, President, in the chair.

MR. PEMBERTON: Of late years a considerable amount of attention has been paid to the metal aluminium. Much has been written about it; many plans have been proposed for its extraction, and numberless patents, embodying these plans, taken out, both in the United States and abroad. In fact, the subject appears to possess a species of fascination, as it has attracted attention from all directions. Parties supplying the raw materials or chemicals used in the experiments report that the demand for such comes not only from chemists and metallurgists, but also from business men, lawyers, and professional men of all kinds. The long list of foreign patents on the subject shows how widely it

WHOLE NO. VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.) 18

attracts interest. Prof. Richards' treatise on aluminium contains fifty-four pages—one-sixth of the entire book—on the manufacture of the metal by processes other than the regular one of Deville.

There is no difficulty in giving an explanation of this. Of all the metals, properly so called, the compounds of which make up the crust of the earth, aluminium is the most abundant. This statement is literally true; there is no exception to it. It is evident, therefore, that there can be no difficulty in obtaining material to work upon. Now, taking ordinary clay as an instance, it can be readily shown that in every cubic yard there is at least 800 pounds of aluminium, the lowest recorded price of which is five dollars a pound. Clay can be had, in many cases, at a cost not exceeding that of digging it out. The apparent profit can readily be calculated.

The practical outcome, however, of all of this work, and of all of these experiments, is that the only process by which any quantity worth speaking about, of the pure metal aluminium—in contradistinction to its alloys—has ever been extracted, is the process of Deville, established about a third of a century ago. Modifications in the preparation of the materials have, indeed, been made. But the main features of the process, and the sequence of operations, have remained unchanged. The large aluminium works now just about starting, near Birmingham, England, employ the same chemicals, and rely upon the same reactions that the French chemist did in the fifties.

This company—the Aluminium Company, Limited—has gone into the manufacture on a scale never heretofore approached. According to the descriptions in a number of English technical journals, the works comprise a plant of twenty furnaces for the manufacture of metallic sodium by the Castner process, with a total capacity of about 1,500 pounds a day; a set of twelve regenerative heating furnaces, containing sixty retorts for the manufacture of the double chloride of aluminium and sodium, turning out about 5,000 pounds every twenty-four hours; a Weldon chlorine plant; and furnaces for reducing the aluminium from the double

chloride by means of the sodium. The total capacity of the works is about 500 pounds of aluminium daily. According to a late number of the *Chemical News*, the production of the entire world has heretofore not been over fifty pounds a day. It appears, therefore, that the new company can manufacture in five or six weeks as much as has hitherto been produced in a year. The selling price of the aluminium has been placed at about five dollars a pound as against eleven dollars, lately. The reduction is due partly to the large scale of manufacture, but principally to the cheapening of the cost of the sodium by Mr. Castner's process. It is to be noted that the aluminium made by this company will be in the form of the pure metal unalloyed. If it is desired to produce alloys, they can only be made, or, at any rate, they have only been made by first manufacturing the metal and then alloying it.

Exactly opposite is the case with the Cowles electric smelting process. Here the aluminium has always been produced as an alloy, with either copper or iron. The manufacture of the pure metal on a commercial scale does not appear to have been successful so far, and it is probable that the large demand for the alloys has prevented proper attention being given to this branch of the subject. There is no inherent reason why the metal itself should not be produced, but as a matter of fact, up to this date, such has not been the case.

There is one point, connected with this process, which is worth drawing attention to; that of the reduction of aluminium from its oxide in the presence of carbon, at a high heat. The discovery of this property of the element was as radical and as unexpected as the discovery of a new oxide would have been. All previous efforts to accomplish this had been utterly fruitless, so much so that the hope of so doing had been almost entirely abandoned. Only a few years before the Messrs. Cowles took out their patents, the late Mr. Walter Weldon asserted that it would be about as sensible to try to get five from two times two, as to reduce alumina by carbon. "Never prophesy, unless you know," said Artemus Ward. This property of the metal is worth

drawing attention to, as the practical results of the new process appear to have overshadowed a discovery very interesting from a scientific point of view.

The electro-smelting process appears to have been making great advances, of late. A description of it was embodied in a Report of the Committee of Science and the Arts of the FRANKLIN INSTITUTE (this JOURNAL, July, 1886). Since this report was published, several improvements have been made. It has been found practicable to tap the furnace, and allow the molten metal to flow directly into the ladle or into slabs, instead of letting it cool in the furnace and then putting it cold into crucibles to be remelted. This has practically doubled the capacity of the plant. Another improvement has been in the use of *beauxite*, as well as *corundum*, for a raw material, thus ensuring an abundant supply of alumina. The works at Lockport, N. Y., have now two dynamos of 217 electric horse-power each, driven by water-power. The new establishment at Milton, England, has a 402 E. H. P. machine, put up experimentally and to be followed by others. Both of these works are reported to be running day and night.

It appears, then, that the aluminium industry has at length attained a firm footing and is well established. The two lines of manufacture differ essentially in their characteristics. One is a chemical process, the other a metallurgical. One produces the pure metal only, the other only its alloys. One is a complicated process, the other a simple one. Indeed, the Cowles process is extremely simple, consisting, as it does, of only the dynamo, with the power to drive it, and the application of its current to the mixture of carbon, alumina and the metal to be alloyed. Compared with this, the Deville process is a very elaborate one. Compared with any process, it is a very elaborate one. Indeed, it is doubtful if in the whole field of chemistry and metallurgy together there can be found any process which involves such an intricate series of operations as this one does. There is a department for preparing the alumina, a department for preparing the iron and carbon compound (Castner's patent), another for manufacturing the metallic sodium, another for

re-working two-thirds of the sodium remaining as carbonate from imperfect reduction. (This, indeed, is done in an adjacent works, but has to be paid for, of course, just the same.) There is a department for manufacturing chlorine by the Weldon process; another for mixing the alumina, carbon, and salt, moulding and drying the same; another for treating this mixture with chlorine at a red heat for the production of the double chloride of aluminium and sodium, and finally one for treating the double chloride with sodium by which the alumina is reduced to metal. The manufacture of some high-priced organic compound—for instance, Fahlberg's saccharin—may approach this, but it is doubtful if it exceeds it. The Solvay process of manufacturing soda-ash has often been cited as one having had a long uphill fight. But the Solvay process had the additional struggle of having to manufacture its product for less than two cents a pound, or else not at all, whereas metallic aluminium is sold for twice as many dollars a pound. It needs no expert to see that the cost of the aluminium in alloys, as made by the electro-smelting process, must necessarily be only a fraction of that of the metal made by the Deville. It follows, therefore, that the latter process will not be likely ever to compete with the former in the manufacture of alloys, but will have as its legitimate field the production of the pure metal. It is dangerous to assert a negative. But it is hard to see how there can be any escape from the above deduction. Perhaps a possible exception may be named in the case of certain alloys of aluminium and silver—such as *tiers argent* and a few others of like kind, used in table ware.

There are three properties, or characteristics of aluminium, that make it valuable in the arts. It is a light metal (sp. gr. 2.56), being about one-third as heavy as iron. It is a pretty metal, and not very readily acted upon by atmospheric influences. In this respect it rivals silver, which is blackened by sulphuretted hydrogen, by which aluminium is not affected. Upon exposure for some time, however, or by handling, the surface loses its brilliancy and becomes, through oxidation, more or less “dead,” resembling tin or zinc, though superior to them, as the color is much whiter.

In the third place, it is a fairly strong metal, about equal to brass. It is destined to play a valuable role in the manufacture of philosophical instruments. Prominent manufacturers state that the weight of theodolites, levels, compasses, sextants, etc., is about one-third less when made of it, and seem to think that there is no doubt of its being largely employed at the quoted English price. All the bearings and wearing surfaces of these instruments must still be made of brass, as aluminium is not hard enough. It is coming into use for making beams of chemical balances with a capacity up to as much as 200 grammes, and has long been used for the smaller weights. The moulds for casting such beams are the same as have been used for the ordinary bronze. Opera- and field-glasses, when made of it, are much lighter and can be used with great ease and comfort. It cannot be employed for cooking utensils, as it dissolves easily in organic acids in the presence of chlorides, such as common salt (Roscoe). A few other uses in which the pure metal appears to advantage, are aluminium leaf, fine wire lace, certain surgical instruments, suture wire, dental plates, etc. Aluminium jewelry has failed to make any headway; it tarnishes too easily and becomes brittle.

It will be observed that nearly all of the above uses are for objects small in size. Many suggestions have been made for its use on the larger scale, as in aërial navigation, or for engineering and constructive purposes. Some of these are of a very sensational nature, as for example :

"The dead weight of trains could be saved by constructing freight and passenger cars of aluminium. * * * Ships larger than the *Great Eastern*, with less draught, could be constructed nearly entirely of aluminium, including the machinery and boilers which at present weigh down vessels seriously. * * * Railway beds, sleepers, ties, rails, bridges, and all, will be cast solidly in their places, with airy aluminium palace cars dancing over them 100 miles an hour or more," etc.

There is a fallacy involved in all such writing, which may be worth showing up. The writer's attention is pre-eminently attracted by the low specific gravity of the metal.

When employed in any construction where it will be required to withstand severe stress, the metal with which it will immediately come into rivalry will be steel. The specific gravity of steel is almost exactly three times that of aluminium. Of course an inch rod of the latter metal will, therefore, weigh only one-third as much as an inch rod of steel. But when we examine the tensile strength of the two we find that steel has three times the strength of aluminium. It follows, therefore, that to make the aluminium rod of the same strength as the steel, it must be three times the size. The two rods will now weigh exactly the same. Where, then, is the advantage of the low specific gravity of the aluminium?

The extraordinary qualities of many of the aluminium alloys have long been known. The bronze is the strongest of cast metals, and when rolled, the strongest of rolled metals. Nor does it corrode as ordinary bronze does, and its fine golden color gives it a very pleasing appearance. Aluminium brass is noted for its great strength, for its extraordinarily high elastic limit, and for its cheapness. Being composed of equal weights of zinc, copper and ten per cent. aluminium bronze, it contains only three and one-third per cent. of aluminium; hence its lower price.

Aluminium iron is now extensively used in the production of wrought-iron castings (Mitis castings). That the fusing point of wrought iron should be reduced almost 500° by the addition of only one one-thousandth of its weight of aluminium, is another instance of the wonderful properties of this extraordinary metal. The effect of its addition to cast iron is shown in a paper on this subject by W. J. Keep. [This JOURNAL, 126, p. 220.] Large quantities are now being used also with steel, a very minute amount ensuring the solidity of the castings. Indeed, it appears that aluminium will be used almost universally in the metallurgy of steel and of iron, including puddled iron. Its strength-giving properties are extraordinary. There is hardly any metal with which it will not alloy. And it alloys with nothing that it does not improve. It would be only tedious to attempt to describe its endless applications.

Two of the most important, however, may be noticed. The bronze is destined to play an important part in the manufacture of cannons. The war that is waging between experts, regarding the relative value of cast and of built-up guns, is so fierce, that it appears difficult to obtain a discussion on the subject that does not involve the introduction of this pet fight. Aluminium bronze can, of course, be used for either type, although the cast gun is naturally much the cheaper. Such cannon could be made to possess almost any desired combination of properties, from 114,000 pounds tensile strength and five per cent. elongation, to 90,000 pounds and 10 per cent. and to 72,000 pounds and 47 per cent. The castings would be free from blow holes, could be poured at a comparatively low temperature, would be free from any separation of the ingredients or liquation and would therefore be of uniform composition throughout. The plant required to construct them would be simple compared to the elaborate establishments necessary in the construction of the steel guns of the built-up type. Unlike these latter, the bronze gun, when worn out, could be melted up and cast over again, as the value of the metal in them is about two-thirds that of a new gun. Aluminium bronze stands this treatment on account of the above mentioned freedom from liquation.

Aluminium brass is now being used by the United States Government for the manufacture of propeller blades for the new war vessels. Various metals have been used for this purpose. Cast iron is too weak. Steel has some admirable qualities, but is very liable to corrosion, the average life of a steel blade being only four years. Ordinary bronze has been used, but is deficient in strength. Manganese bronze has, until lately, headed the list. Our Government, therefore, ordered the propellers to be made of this metal. Attention, however, was drawn to aluminium brass, and numerous comparative tests were therefore made, with the following results: *

	<i>Mang. Bronze.</i>	<i>Al. Brass.</i>
Tensile strength per square inch, tons, . . .	29 — 31	34 — 50
Transverse " " " " " cwts., . . .	28 — 52	75 — 85
Price per ton in ingots, ...	£112	£103

* See *Engineering*, London, April to June, 1888.

The order for manganese bronze was accordingly countermanded, and aluminium brass adopted in its stead.

It is difficult to speak of these alloys without appearing to be guilty of extravagance; their quality is so uniformly excellent, their appearance so fine, their uses so many. But hundreds and hundreds of tests, similar to those above given, have been made, both officially and in private, and the results obtained have invariably substantiated all that was claimed for them. The chemical process at Birmingham also has a wide future before it. It can hardly be said to have more than started as yet, and the introduction of its "silver from clay" will naturally require time. Much is owing to chemistry for what it has done in the extraction of this elusive metal. But it cannot be denied that the value of aluminium in the arts will be chiefly in its alloys, and that the greater debt of gratitude is due to that protean and subtle form of motion known as electricity.

ALUMINIUM.

BY HANFORD HENDERSON, Professor of Chemistry and Physics, Philadelphia Manual Training School.

[*A lecture delivered before the FRANKLIN INSTITUTE, Monday, January 9, 1888.*]

Prof. HENDERSON was introduced by Dr. PERSIFOR FRAZER, Professor of Chemistry in the INSTITUTE, and spoke as follows:

LADIES AND GENTLEMEN:

It is my purpose, this evening, to speak to you for a few moments on the subject of aluminium, an element whose name is to-day in almost everybody's mouth. You may have observed that in different mouths it has taken different forms. From some we hear of it as aluminum, while others are always careful to say aluminium. On grounds of both euphony and historic usage the longer name has, I

think, decidedly the preference. The substance of the element, unfortunately, has not attained so common a currency as its name. It has been called, and not without propriety, "the metal of the future." There is a dual significance locked upon in this designation. The metal is so almost noble in its qualities, so useful in its application to the arts, and in all respects so much to be desired, that as we wish all good things for the future, so we wish for it, aluminium. Had it been known in Sir Thomas More's time, it would undoubtedly have been the only metal used by the Utopians. But it is also the metal of the future in another and much less desirable sense. So persistently has it resisted the best skill of our metallurgic art, that it has taken some faith to believe that the metal would not always belong to the future and never to the present. However, ours is a progressive age, and the metallurgy of aluminium, though somewhat sluggish, does advance perceptibly. Our knowledge of the problem is to-day a little greater than it was yesterday. To-morrow, we may reasonably hope, will find our store of still better dimensions. The work of the past few years has been particularly encouraging. In calling your attention to this promising though somewhat elusive metal, therefore, I do so from a belief that the subject is one of growing importance, and will in time merit the share of interest you may bestow upon it.

You are acquainted, I doubt not, with the story of Tantalus. The position of the chemist in quest of aluminium is almost as unfortunate. The metal he seeks is all around him. He can scarcely move without treading on some of its compounds. Yet it eludes his eager pursuit, like some metallurgical will-o'-the-wisp. It recedes from his touch with almost the same persistence as the water and the fruit from the unhappy King of Phrygia.

Iron is the symbol of our present material civilization. It is among the most abundant of metals. It is, indeed, everywhere, for it is the great pigment of nature. It paints our sandstones brown; our bricks, red; and our clays, yellow. You can scarcely get out of the sight of it. But this comparatively new metal, aluminium, is even more abundant.

We do not know of what the centre of our great whirling earth is made. As the globe, taken as a whole, is between five and six times as heavy as water, while the rocks open to our study are only about two and a half to three times as heavy as that standard, we may not unreasonably suppose the core to be composed of the heavier metals, iron, lead, zinc, perhaps silver, gold and platinum. Of the composition of the surface of the earth, however, we have more definite information. Oxygen, the gas upon which life itself depends, makes up about one-half of these rocks; silicon, the basis of ordinary sand, about one-fourth, while aluminium stands third quantitatively in our recognized list of seventy odd elements. You see how relatively abundant this metal is in combination with other elements. And not only is there a great deal of it in absolute quantity, but the forms in which it occurs in nature are also correspondingly numerous.

Mineralogists have described and named nearly a thousand different minerals. In more than two hundred of these, aluminium occurs as an essential constituent. With many of its more beautiful forms you are doubtless familiar. It does not paint with the generous hand of iron, but it is a far more subtle colorist. There is scarcely a gem mineral, outside of the diamond and the rock crystal, that does not contain aluminium. The brilliant sapphire is an oxide of the metal. Of similar composition are the oriental ruby, the oriental topaz and the commoner form, corundum. Add a little iron to this and we have the valuable abrading material known as emery. The real ruby and the much prized gem, alexandrite, are compound oxides of the metal. Among the silicates it occurs in nearly all the known varieties, from the common clays and other rock-forming aggregates to such royal gems as the emerald, the garnet, the lapis-lazuli, the party-colored tourmalines, and the topaz. As a hydrous phosphate, it gives us the turquoise, one of the most beautiful among the mineral blues.

I had in my possession at one time a very interesting ring. The band was made of aluminium, and displayed a fine oriental ruby, thus illustrating to excellent advantage the appearance of both the metal and its oxide.

These treasures, however, constitute a very inconsiderable part of the earth's surface. It is made up, for the most part, of much commoner stuff, and it is with this that the metallurgist has to deal. Of the many forms of mineral compounds in which aluminium occurs, there are but four which are at present made the subject of his skill. These may properly be termed ores of aluminium. They are: corundum, the common oxide, which occurs in some plenty in the mountains of western North Carolina; cryolite, the double fluoride of aluminium and sodium, which is brought to Philadelphia by the shipload from Arksut Fiord, in Greenland; beauxite, the hydrated oxide of aluminium and iron, which occurs abundantly in Southern France, and kaolinite, or common clay, the silicate of the metal, which is found almost everywhere.

In nearly all of the older rocks we find an appreciable amount of gold. In the soils derived from the disintegration of these masses, the same precious metal is to be found. Some one has taken the trouble to calculate that the clay underlying Philadelphia contains at least \$15,000,000 worth of gold. But as it would take many times this sum to effect its extraction, the metal is likely to remain where it is. No one, I believe, has had the courage to calculate the value of the aluminium contained in the same clay beds. I shall not tax you with such a calculation, but I will ask your patience with a few figures that I have used for a less extended computation. I believe that they will do more than anything else I can say to impress you with the commercial value of the metal, and the present state of our chemical knowledge concerning its extraction. I am going to ask your attention, not to the vast amount of clay underlying our city, but to a single cubic yard of that material. I give the calculation in detail, believing that some of you who are not familiar with such processes may not find it uninteresting.

A cubic foot of water weighs approximately sixty-two pounds; consequently a cubic yard of that fluid will weigh 1,674 pounds. The specific gravity of clay may be taken at 2.5. The weight of a cubic yard of clay therefore would be

two and a half times the weight of the same volume of water, or 4,185 pounds. There is about forty per cent. oxide of aluminium in ordinary clay and about fifty-six per cent. of metal in the oxide, so that a cubic yard of clay contains about 937 pounds of metallic aluminium. At \$12 a pound, an average price, this is worth over \$11,000.

This result is rather surprising. Let me repeat it. One cubic yard of ordinarily pure clay contains an amount of aluminium for which society is willing to pay over \$11,000.

Nature is full of challenges to our inventive skill, and our powers of observation and reasoning. Not an apple falls to the ground in any quiet country orchard that does not challenge us to find out why it falls. The youngest school-child will tell you very glibly that it is the force of gravitation. But press him a little further, and ask him what is the force of gravitation, and he will be silent. He cannot answer your question. Neither can his masters. We do not know. These every-day, unexplained facts of nature seem to me like so many giant interrogation points constantly staring us in the face.* Even the clay, you tread under foot, is, you see, in an humbler, though more practical way, another of nature's challenges.

Aluminium has indeed been called "Silver from Clay," a name referring to its appearance and origin. But you must not be under the impression that because this clay silver costs about as much as the real silver, no efforts have been made to accomplish its easier extraction. I presume that there is not a single chemist the broad land over who has not, at some time—more probably, perhaps, when he was young—given serious thought to the problem. And to-day, I think I may say without exaggeration, that there are hundreds of earnest workers seeking its practical solution. Nor have their joint results been insignificant. There was a time when the metal in this same cubic yard of clay would have been worth twenty-two, or forty-four or even sixty-six thou-

* Although in these days it requires more courage to declare a thing impossible, than possible, Prof. Helmholtz has recently expressed the opinion that gravitation is incomprehensible, and Mr. Herbert Spencer has long regarded it as belonging to the Unknowable.

sand dollars. There was a time before that when it could have been obtained for no price, however fabulous; and a still earlier time when the very existence of a metal such as this was unsuspected.

To present the outlines of this progressive history, and to familiarize you in some slight degree with the appearance and properties of a metal in whose rising fortune I have so great a confidence, are the full measure of the evening's ambition. So far as I am aware there is absolutely nothing original in what I shall have to say. My "interest" in the metallurgy of aluminium, is the same in kind, as your own. It has no market value.

The great French chemist, Lavoisier, seems to have been the first to suggest the existence of metallic bases in the soils and alkaline earths. Sir Humphrey Davy, of safety-lamp fame, attempted to verify the truth of the suggestion, but though he succeeded in isolating the alkaline metals, sodium and potassium, by means of electricity, he failed to separate aluminium. Oersted, in 1824, came very near to the solution of the problem. Indeed, it is an open question whether he did not isolate the metal, but as his method did not give satisfactory results in the hands of other experimenters, the fame of the discovery of aluminium is generally accorded to Wöhler, who, in 1827, decomposed the chloride of aluminium by means of metallic potassium. Here the matter was permitted to rest until 1845, when the German chemist resumed his investigations, and by allowing the vapor of the chloride to pass over potassium contained in platinum receptacles, obtained globules of the metal of sufficient size to enable him to determine its principal properties. It was, however, less fusible than cast iron, and had the disadvantage of decomposing water at ordinary temperatures, two qualities which gave little promise of the future usefulness of the metal, even should it ever be isolated in sufficient quantities to enter the markets. It has since been found that the infusibility of Wöhler's metal was due to the platinum with which it was alloyed; and the ease with which it decomposed water, to the probable presence of either potassium or the unchanged chloride of aluminium.

And now we come to the epoch of greatest moment in this metallic history. In 1854, the genius of Henri St. Claire Deville was attracted towards the possibilities offered by the new metal. It came about, as we express it, by accident. Deville was experimenting upon the salts of aluminium, and for purposes of the work in hand attempted to prepare the metal according to Wöhler's earlier method. He failed in the original purpose of his experiment, but succeeded in obtaining globules of very pure metallic aluminium, and in determining for the first time its true properties. He was thus led to admire the beauty of a metal with which his name has since been inseparably associated: and to devote his large knowledge to an attempt to make the metal available for human uses. It was Michael Angelo who said: "Genius is infinite patience," and its truth was beautifully illustrated in the case of Deville. He applied himself to his chosen task with uncommon persistence and with uncommon results. He did his work with such thoroughness that only the cheapening of electric energy has enabled us to increase the store of information which he bequeathed to succeeding metallurgists. His first step was to supplant potassium by the cheaper and less dangerous metal sodium. By improvements in the manufacture of this indispensable reagent, he reduced its cost to a mere tithe of what it had formerly been. In the production of the chloride of aluminium he also introduced better processes, and by carrying out Wöhler's reaction, thus modified, on a large scale, Deville placed aluminium on the list of commercial products. During the latter part of his work, he enjoyed the patronage of the Emperor Napoleon III, who was chiefly actuated, it is said, by the hope that the extreme lightness of the metal would make it valuable in naval warfare. At the Paris Exposition of 1855, it was first exhibited in public. A large bar of the metal was shown, bearing the title, already quoted: "Silver from Clay." The first article made of aluminium, of which I find any record, was a baby's rattle, for which the material, on account of its extreme sonorousness, was admirably adapted. It was intended for the Prince Imperial, the poor boy who afterwards lost his life in Zululand.

France has ever remained the home of the aluminium industry. Of recent years, it has also developed to an encouraging extent in England. It has gained but a limited hold among the activities of Germany, Switzerland and the United States.

The methods of preparing metallic aluminium in vogue at the present time do not differ essentially from those of the past. If they have any distinctive feature, it lies in the completeness and perfection with which the various details have been worked out. It is in this humble, though all-conquering way, that the successes of to-day have been achieved. If one were to seek out all the methods, proposed as well as provided, for the isolation of aluminium, the task would be much more difficult than the one I have undertaken. But as our purpose includes only the consideration of those processes by which the market is actually being supplied, I shall sufficiently tax your patience if I ask you to regard the three methods of reduction which now divide the attention of practical metallurgists. These are: (1) Deville's method in its modern form; (2) electric methods, which include both those in which the current is used simply as a source of intense heat, and those in which the selective action of electrolysis is utilized, and (3) that indefinite though promising class of methods, which may be summed up under the general name of projects.

At the present time nearly all the metallic aluminium produced is made according to Deville's method. It is the sole source of the metal in France and in England, and, indeed, it has recently been so greatly improved that unless some exceedingly advantageous method of reduction is proposed, it promises to remain so. The study of the metallurgy of aluminium is therefore largely covered by the study of this one method. There are three distinct operations involved in the process:

(1) The preparation of the double chloride of aluminium and sodium.

(2) The preparation of metallic sodium.

(3) The production of metallic aluminium by the reaction between the double chloride and the sodium.

The manufacture of the two necessary reagents is the most tedious, as well as the most expensive part of the entire process. The effort of inventors has therefore been chiefly directed towards the improvement of these preliminary operations.

At the great French establishment at Salindres, the crude material employed is the mineral *beauxite*, the hydrated oxide of aluminium and iron. It is finely pulverized and then thoroughly mixed with sodium carbonate. The mixture is strongly calcined in a reverberatory furnace, by which the aluminium is converted into a soluble aluminate of soda, while the iron remains as the insoluble sesqui-oxide. By washing with warm water, the two are easily separated. The aqueous solution of the aluminate is then treated with carbon dioxide gas, which precipitates the aluminium as a hydrated oxide, and regenerates sodium carbonate. A second filtration and washing separates the two. To convert alumina thus prepared into the double chloride of aluminium and sodium, it is mixed with carbon and common salt, chloride of sodium. The mixture is made as homogeneous as possible, and formed into balls as large as a good-sized orange. These are thoroughly dried at a temperature of about $150^{\circ}\text{C}.$, and are then packed into earthenware retorts, where they are calcined at a red heat. Meanwhile chlorine gas is introduced into the bottom of the retorts. The double chloride of aluminium and sodium is thus formed, and volatilizing, passes over into earthen pots, where it condenses and may be stored away for future use. The simple chloride of aluminium was employed in the early days of the industry, but as it is deliquescent, that is absorbs moisture from the atmosphere, it is difficult to preserve, and has been almost if not entirely superseded by the more convenient double chloride. The formula of this salt is $\text{Al}_2\text{Cl}_6, 2\text{NaCl}$.

A somewhat different method is in use at the English aluminium works at Birmingham. Alum is there employed as the crude material for the production of the double chloride. It is mixed with coal pitch, and calcined at a low temperature. Water is driven off, and sulphur, potash and

alumina remains. After subjecting the residue to the action of steam and air, at a low red heat, it is placed in a vat of hot water. The potash is thus dissolved out, and the insoluble alumina collected and dried. It is then converted into the double chloride by the usual process.

The second operation in Deville's method is the preparation of metallic sodium. As commonly carried out, the operation presents no great difficulties, but it is wasteful and therefore expensive. I give it in some detail, because I want you to fully appreciate the cleverness of an improved method devised by one of our compatriots, which promises to radically change the conditions of the aluminium industry in Europe. The older process, then, consists in reducing sodium carbonate by means of charcoal. As the carbonate is easily fusible, were the two simply heated together, the result would be that the carbon would float on top of the liquid mass, and, consequently, fail to accomplish its work of reduction. It is, therefore, necessary to add about fifteen per cent. of lime, in order that the mixture shall remain infusible and the carbon and soda be kept in contact with each other. The three reagents are mixed as intimately as possible, and subjected to a preliminary calcination at a red heat. This makes the mass more compact, and removes a considerable amount of carbon dioxide. It is afterwards placed in small wrought-iron cylinders and heated to a temperature of perhaps $1,400^{\circ}$ C. At this heat the reaction between the soda and charcoal takes place; the alkali is reduced and distils over into suitable condensers. Only about two-fifths of the metal contained in the charge is recovered. The greatest waste, however, is in the labor, the wear and tear of the "plant," and the fuel required to attain so high a heat. All of these causes combined have made sodium an expensive metal. It has been selling in this country for \$1.50 a pound, and it has been calculated by a competent English chemist that on the other side of the water it costs four shillings per pound to produce. As it takes something over three pounds of sodium to make one pound of aluminium, it will be seen that this item alone is largely responsible for the high price of the metal. Cheap sodium means comparatively cheap aluminium.

The improved process, to which I have alluded, is that invented by Mr. H. Y. Castner, of New York City. It has not been the result of chance, but of elaborate and systematic experimentation. Mr. Castner, I understand, was attracted to the aluminium problem, while he was yet a student at Columbia College. After an examination into the conditions of its metallurgy, and the possible directions for improvements, he came to the conclusion that the most probable field for better things lay in the cheaper production of sodium, and accordingly he devoted himself to that. I think he worked on the problem for a couple of years. The result of his work has been the production of a process so admirable that the only fault I have to find with it is that I did not invent it myself. Others have felt the same towards the process and from both sides of the Atlantic warm praise has been bestowed upon it and upon its inventor.

The germ of Mr. Castner's improvement is simplicity itself. Instead of making use of an infusible mixture, so that the carbon and sodium compound should be kept in contact, he has obtained the same result by a much more rational device. The little particles of carbon are weighted by means of particles of iron, and so, instead of floating uselessly on the surface of the sodium salt, mix through the whole mass and accomplish their work of reduction under much less wasteful conditions. The improvement you see belongs to the domain of physics and consists of so simple an expedient as increasing the specific gravity of the reducing agent until it equals or somewhat exceeds that of the fused salt. The process is not in use in America at the present time, but has been warmly welcomed in England. Large works are being erected at Birmingham, where both sodium and aluminium will be final products.

Caustic soda is used in preference to the sodium carbonate. The reaction is represented with sufficient accuracy by the following equation:



The carbide of iron here symbolized is replaced in

the practical working by a specially prepared mechanical mixture, which is found to act as a perfect equivalent. The so-called "carbide" is prepared by mixing together definite amounts of finely-divided iron and melted pitch. When the mixture cools, it is broken in pieces and coked in suitable retorts. This finely ground metallic coke is the reducing agent which has solved the problem of cheap sodium. The reduction is carried out in capacious cast-iron crucibles. The charge consists of caustic soda of the highest obtainable strength and the proportion of so-called "carbide" needed to satisfy the formula given.

The charged crucibles are placed in a small furnace where they are moderately heated for about thirty minutes. The mass fuses, and for a time boils with considerable violence, owing to the plentiful escape of hydrogen. At the end of the preliminary heating, the fusion becomes quiet and the crucibles are transferred to the distilling furnace. Here each crucible is placed upon a small elevator platform and is raised into position. The covers of the crucibles are stationary, and are made with convex edges. The crucibles themselves have grooved edges in which a little powdered lime is placed. By simply raising them into the furnace they are effectually sealed during the process of distillation, and may readily be detached when that process is completed and a freshly charged crucible is wanted. Tubes project from the stationary covers and lead to the condensers where the distilled sodium again solidifies. The hydrogen escapes from a small opening in the opposite end of the condenser, and is generally lighted in order to show how the distillation progresses. The operation lasts about an hour and a half and is carried out at a temperature of about 825° C. instead of $1,400^{\circ}$ as in the older method. The residues consist mainly of carbonate of soda and metallic iron, both of which are again utilized in future distillations, the one in the form of caustic soda, the other in the reducing "carbide." The whole process is extremely simple and ingenious. It will produce metallic sodium at a cost of less than one shilling a pound. The English company, which is now putting the process into commercial

operation promises to place aluminium on the market in a few months at a price not greater than \$5 a pound. If this can be done successfully, the uses to which the metal is put will be greatly increased, for it is making its way in certain fields at more than double that price.

I have dwelt upon Mr. Castner's invention with particular pleasure, both because it comes from a thinking rather than a so-called "practical" man, and because it is so neat a solution of a difficulty of somewhat long standing that it should encourage others to attack similar problems in the faith that equally simple solutions are to be found, if one will but look with sufficient persistence.

We have now come to the third operation in Deville's method, the utilization of these expensively won reagents in the final reaction by which metallic aluminium is produced. A difficulty which beset the early metallurgists was the provision of a flux sufficiently light to permit the reduced metal to sink to the bottom of the reducing hearth, and so unite into an available mass. This is now met by the use of cryolite, which serves the purpose to excellent advantage.

The furnace in which the reaction is carried out is a small affair, built after the reverberatory pattern. It is securely bound together by iron tie-rods, for the interior of the furnace during the operation is the scene of pretty severe cannonading. When the double chloride of aluminium and sodium is brought into contact with metallic sodium in the heat, the sodium, by virtue of its greater affinity for chlorine, displaces the aluminium, setting it free in the desired form of a metal, while the chloride of sodium so formed unites with the cryolite and forms a very light and fusible slag. The reduced metal is run off into moulds and at once cast into marketable ingots. A portion of the slag contains enough aluminium in the form of scattered shots of metal to make its re-working profitable.

In these days when the electric methods are promising so freely and so much, it is common to regard Deville's method as rather a thing of the past, but as it has produced, and is still producing, the bulk of all the aluminium in the

markets, I think it not unwise to go on the principle that "a bird in the hand is worth two in the bush," and familiarize oneself with what is actually being accomplished before devoting one's attention to those achievements that are expressible only in the future tense. This is my excuse for having considered at such length an "old-fashioned" but constantly improving method.

In the employment of electricity in the reduction of aluminium there is, at the present time, an atmosphere of hope rather than of realization. Of its ultimate success one can hardly doubt, who has watched its course in other fields. It presents to us a power that furnishes at once an intense heat, or an ability to control chemical action, that is almost irresistible. The Cowles process depends upon the first of these functions, while all electrolytic methods, as their name implies, depend upon the latter.

It is quite within limits, I think, to say that the Cowles process is the most important among all the electric methods. It does not, at the present time, produce pure aluminium, but simply alloys of the metal with copper. These, however, are of such high value that they deserve all of the attention that they are now receiving. The ore used in this process is preferably the corundum obtained from the Southern States. The furnace in which the reduction is carried out is, in its simplest form, a rectangular box of fire-clay, lined with powdered charcoal. The electric terminals are huge arc-light carbons projecting from each end of the furnace. The space between the ends of the terminals is filled with a mixture of ore, granulated copper and coarsely pulverized carbon. When the current passes the resistance offered by the carbon causes so intense a heat that the oxide of aluminium is reduced, and the metal formed unites with the now molten copper. It will be observed that the passage of the current is continuous, and that its only function is to produce a heat far more intense than that obtainable by ordinary processes of combustion. The result of this electric smelting is an alloy containing anywhere from a few per cent. of aluminium up to forty or more. It is cast into ingots, analyzed and re-melted with

sufficient copper to form an aluminium bronze of the desired proportions. The electric furnace has been of late much improved and many refinements introduced into the process. These have made it a commercial as well as a scientific success. As power is the great desideratum, the Cowles Company has located its new works at Lockport, N. Y., where it has available water pressure to the amount of 1200 horsepower. To those who are sensible of the wonderful beauty of the correlation of forces, there is something highly instructive in this quiet transformation of the power stored in a water-fall into mechanical motion, into electricity, into heat, until it finally loses itself in the work of chemical dissociation. I understand that at the present time it costs by this method something less than forty cents per pound to produce the metallic aluminium in the alloys now on the market. They are sold, the company informs me, at the rate of three dollars per pound, with the copper at the market rates. As one of the chief uses of the metal is in the aluminium bronze thus produced, the Messrs. Cowles have solved a very important problem in the metallurgy of aluminium. The process having been so successful in the production of alloys of the metal, it has not unnaturally aroused the hope that it might become a source of the pure metal itself. The function of the copper is to collect and preserve the aluminium as it is reduced. Were it absent, difficulties would arise in the collection of the metal and also from the fact that it would unite with the carbon to form a yellow, crystalline carbide of aluminium, which would require subsequent treatment. It is believed that the copper and aluminium form a true chemical compound, for their union is attended with the disengagement of heat. It is improbable, therefore, that they can be readily separated by any liquation process. There are other metals, however, with which this would be possible. Tin is one of these. When this metal takes the place of copper in the electric smelting, an alloy of tin and aluminium is produced, which, on being subsequently melted with the proper proportions of lead, yields a metallic bath consisting of an alloy of tin and lead beneath and a layer of pure aluminium above. The perfecting of

this process promises an abundance of the pure metal at a very low price. It is not yet carried out on the commercial scale, but I understand is at present the subject of very careful and persistent study. That it may meet with the most ample success, is the wish of all chemical spectators—except those who have rival processes in mind.

Still another modification of the Cowles process has been brought into vogue by the requirements of the Mitis castings in wrought iron. It consists in the substitution of iron for copper, and the consequent production of alloys of aluminium and iron. Only a few years ago the expression “wrought-iron castings” would have been received with incredulity if not ridicule. The high temperature at which wrought iron melts and the difficulty of keeping it sufficiently fluid to cast with any success have limited the working of the material almost entirely to forge processes. Mr. Peter Ostberg, a Swedish engineer, has, however, so far conquered these conditions that the Mitis castings are now to be found in the regular metal market. He has won this victory by means of aluminium. An alloy always melts at a much lower temperature than the average fusing point of its constituent metals. Wrought iron melts approximately at $4,000^{\circ}\text{F}.$, but if even a fraction of one per cent. of aluminium be added, the needed temperature is reduced by at least 500° . It is on this principle that the Mitis castings are made. To fluid wrought iron, a small amount of metallic aluminium is added, whereby the fusing point is reduced to about $3,500^{\circ}\text{F}.$ But the temperature of the resultant alloy is little below $4,000^{\circ}$. The thermal difference, or degree of super-heating, permits therefore a leisurely and accurate casting before the metal approaches its point of solidification. The presence of the aluminium is stated to have no disadvantageous effect upon the metal, but rather to increase its tenacity. Although such small quantities are used, the present costliness of aluminium would be a serious disadvantage to the process, but as an alloy of iron and aluminium serves the purpose equally well, the Cowles product is utilized and the two processes become mutually helpful.

In the electrolytic methods, Germany and Switzerland have particularly exercised their ingenuity, although there have not been wanting inventors in the United States who have worked in the same direction. There are any number of methods, distinctive at least in their name, if in nothing else. Sir Humphrey Davy, in the early part of the century, attempted to isolate aluminium by means of electricity, and failed. Both Deville in France and Bunsen in Germany, as early as 1854, electrolyzed the fused double chloride of aluminium and sodium. Since their time the cheapening of the electric current has made the method more practicable. At the present time, however, I know of no aluminium made in this way. The experiments of Dr. Kleiner, of Zurich, have attracted favorable comment and may give rise to an industrial operation. He subjects a bath of fused cryolite to electrolytic action. In Germany the process of Richard Grätzel appears to be the most promising. I have seen beautiful specimens of the metal made by that process, but I am informed by the New York agent of the company operating it, that at present all work is experimental. They hope soon to put their product on the market and will also supply magnesium in commercial quantities.

All of these methods differ from each other, if they differ at all, in the special form of apparatus used, which is supposed to effect a more economical utilization of the current. In principle they are the same, depending simply upon the dissociating action of electricity upon fused compounds of aluminium. The metal collects on the negative electrode. The electrolysis of aqueous solutions of aluminium salts is readily accomplished, but is far too expensive a source of the metal to be industrially available.

Of those various schemes which I have summed up under the name of projects, it is more difficult to speak, for their name is legion. The high prize which awaits the successful inventor of a cheap process for the reduction of aluminium has attracted a class of metallurgical adventurers. They have tried nearly everything that is possible, and have proposed nearly everything that is impossible. The regret which I would otherwise feel in my inability to present all

of these schemes to your attention, is therefore tempered by the consideration that such completeness would not be desirable. It is quite possible that with time some of these propositions will mature into industrial operations. In the absence of any prophetic indications to that effect, however, it will be best to limit our view to one or two processes which have a contemporary interest.

At the present speaking there is but one establishment in the United States where pure aluminium has been a regular commercial product. It is that of Colonel William Frishmuth, at Frankford. It is represented to-night by an admirable display of the metal in the form of ingots, bars, plates and wires. I am unable to state with any definiteness the manner in which the metal has been obtained, for Col. Frishmuth deems it wiser to withhold this information from the public. His older method consisted in a modification of Deville's. Metallic sodium and a volatile salt of aluminium are generated in separate retorts, and brought together while still in the state of vapors, in a third retort, where the reduction takes place, and metallic aluminium is precipitated. He tells me that his present method is a combined smelting and electric one, which promises an excellent and inexpensive product. I am not able to speak of it from personal inspection. This small American establishment has an historic interest from being the place where the aluminium cap of the Washington Monument was cast.

And now it remains for us to consider specifically the advantageous properties which warrant so expensive and so troublesome a metallurgy. I cannot do better perhaps than to refer you to the metal itself for answer. Like all good things, it is its own best advocate. But like them again, its entire merits only appear on very long acquaintance. It will, therefore, be well to enumerate them somewhat systematically.

Physically, then, aluminium possesses properties which distinguish it from all other members of the metallic family. When pure, it has a fine white color, a trifle blue when compared with silver. It is on the whole very pleasing, and

well adapted for ornamental usage. Unlike copper or other base metals, it has neither odor nor taste. It is sufficiently malleable and ductile to be beaten out into very thin foil or drawn into exceedingly fine wire. Of the sturdier properties, aluminium has its full share. It is elastic, exceedingly tenacious, and when hammered, quite as hard as iron. It possesses also a characteristic sonorousness, which leads to the expectation that it may sometime become an advantageous constituent of bell metal.

But the physical property upon which our hope for the future usefulness of aluminium chiefly rests, is its very small specific gravity. It is but 2.56 times as heavy as water. The significance of this levity will appear more strikingly when comparison is made with some of the more common metals. Thus aluminium is only about a third as heavy as iron, less than one-fourth as heavy as silver, and little more than an eighth as heavy as gold. You will have a still more feeling realization of this difference on handling these two slabs of metal which Col. Frishmuth has kindly had cast for me. They possess the same volume, but one is of lead and the other is of aluminium, and one is almost five times as heavy as the other. In considering the costliness of aluminium, its levity must be kept in mind. With both metals at a dollar an ounce, a cubic inch of silver would cost over four times as much as a cubic inch of aluminium.

It would be quite safe to leave to your imagination the manifold advantages possessed by a metal at once so light and so strong. Among the smaller articles which one is called upon from time to time to carry about with him, such as watch, compass, opera-glass, barometer, surveying instruments and the like, the difference between a light and a heavy material is often the difference between comfort and discomfort. The superiority of an aluminium barometer over one of brass weighing about three times as much will not appeal to you very forcibly on casually handling the two, but carry them on successive days over a rough trail, and your opinions will be more pronounced. In more mathematic surveying work, the weight of transit, level or theodolite, is no small tax upon the user. If the consideration be

carried to the more serious problems of portability, the importance of light constructive material looms into still greater prominence. In all of our systems of transportation, by land or water or air, the movement of such large masses of dead weight is an economical evil. The wagon is disproportionately heavy, compared to its burden of freight. A train of vestibuled Pullmans is almost as ponderous when empty as when full. The ocean greyhound carries thousands of tons on each transatlantic passage on which no freight is paid. And so one might follow the entire list of portables and observe the immense advantage that would result from the introduction of a metal as light as porcelain and as strong as steel. We might press the question still further, and speculate upon the greater speed at which so light a train might safely be run, since its diminished momentum would permit it the sooner to be brought to rest.

The metal does not, however, need to be in motion to display the merit of a small specific gravity. In our present structures of iron we have almost reached the limits in the way of possible dimensions. Any further increase in size would be followed by a collapse resulting from the mere weight of the material itself. Could this be reduced two-thirds, and the strength remain unimpaired, one can easily foresee the advantage. There is still another direction in which a small specific gravity means something. This is in the construction of delicate analytical balances. By making the cross-beams of aluminium they are almost perfectly rigid and unalterable, and the centre of gravity of the system is considerably lowered, with a resulting increase of delicacy. Messrs. Troemner & Co., of this city, now construct their finest balances in this fashion, and also employ aluminium for the smaller weights. It may be of interest to know that two such balances form a part of the equipment of the princely laboratory which Mr. Edison has recently erected on the Orange Mountain.

A word should also be said concerning the behavior of aluminium towards heat. At any ordinary temperature, it is absolutely fixed, becoming fluid at about 750° C. It is a

good conductor of heat, and consequently of electricity. It has a larger specific heat than any other of the useful metals; that is to say, it requires a longer time to become either heated or cooled. Deville has suggested that by virtue of this property a plate of aluminium would make a good chafing dish.

In its chemical properties, aluminium is not less remarkable. The most useful of these is its complete indifference to the action of either air or water, and its failure to unite with sulphur under ordinary conditions. A metal which will not rust possesses a manifest superiority over iron and copper or any of the so-called base metals. It was this property which determined the selection of aluminium for the apex of the Washington Monument. As the metallic oxides are poor conductors of electricity, it is important to have a metal for the tips of lightning rods which will not oxidize, and aluminium would be well adapted for the purpose. As a constructive material, a metal which may be freely exposed to the elements without suffering harm needs no praise. As a simple saver of labor it appeals to our philanthropic feelings. When one recalls the multitude of tired arms that daily struggle with the base affinities of brass and try to wring from it an evanescent glitter, the mere thought of a metal which would dispense with this frictional devotion brings a sensation akin to restfulness. In resisting the action of sulphur, aluminium possesses a merit much above silver, which, as you know, blackens on the slightest contact with that element. Spoons and dishes of aluminium are particularly suitable therefore for eggs and other foods containing sulphur. One more mention, and I will close, without however exhausting this catalogue of virtues. In its behavior towards the acids, the metal we are considering shows itself a base of weak affinities. It dissolves very readily in hydrochloric acid, but is almost untouched by nitric and sulphuric. As a substitute for platinum, therefore, in the Grove cell, it has been found to work very well. Towards the weaker acids, such as acetic, it manifests a like indifference, a neutrality which well adapts it for the construction of culinary vessels.

If I have succeeded, by this sketchy statement of the uses of aluminium, in persuading you that the metal is one well adapted to nearly all possible uses, either æsthetic or utilitarian, I have succeeded in making current an opinion which I entertain myself.

I have already spoken, I fear, beyond the proper chronometric limits. Yet I cannot conclude without first anticipating that criticism of incompleteness, which in view of this partial presentation of the subject would be quite justifiable. I am entirely conscious that I have given but a fragment. Into the heights and depths of aluminium, we have scarcely penetrated. In giving this superficial view, however, I have tried to present that side of the cube which most nearly touches the daily affairs of life. By way of caution, I should perhaps add that this view is more favorable than that held by many sober-minded scientists, I do not wish to impose my own enthusiasm upon your better judgment, but for myself, I have great confidence that before many years shall have passed, some chemist will arise among us who shall succeed in transforming by his subtler alchemy, aluminium, the metal of the future, into aluminium, the metal of the present.

NOTE.—The lecturer takes this opportunity of expressing his indebtedness to Messrs. Tiffany & Co.; to Mr. Peter Ostberg; to Col. Wm. Frishmuth; to Messrs. Queen & Co.; to Messrs. Troemner & Co. and others, for their kindness in furnishing specimens of aluminium for exhibition.

TWO REMARKABLE ASTRONOMICAL COINCIDENCES.

BY L. D'AURIA.

Let s represent the mass of the sun, and c the coefficient of attraction. Then if a body begins to fall toward the sun's centre from a distance D , the acceleration of such body at the end of a fall x will be

$$\varphi \frac{cs}{(D-x)^2};$$

and its velocity u can be deduced from the equation

$$\int u \, du = \int \varphi \, dx = cs \int \frac{dx}{(D-x)^2}.$$

Integrating between the limits D and x , and observing that when $x = 0$ must be $u = 0$, will be found

$$u = \sqrt{\frac{2csx}{D(D-x)}}. \quad (1)$$

On the supposition of $D = 2x$, this formula becomes

$$u = \sqrt{\frac{cs}{x}};$$

which is the velocity of a planet revolving around the sun at a mean distance x .

Hence it follows the proposition:

"If a planet be transported to twice its mean distance from the sun's centre and then is let fall toward such centre, it will reach its mean distance again with a velocity toward the sun equal to its mean velocity around the sun."

Let t represent the time a body at a distance D from the sun's centre requires to fall a distance x toward such centre. Will be

$$t = \int \frac{dx}{u},$$

u being the velocity acquired at the end of the fall x . Sub-

stituting for u its value (1), we have

$$t = \int \frac{dx}{\sqrt{\frac{2csx}{D(D-x)}}},$$

which gives

$$t = \sqrt{\frac{D^3}{2cs}} \left\{ \sqrt{\frac{x}{D}} - \frac{x^2}{D^2} + \arcsin \left(\sqrt{\frac{x}{D}} \right) \right\} \quad (2)$$

On the supposition of $D = x$ this equation is reduced to

$$t = \frac{\pi}{4} \sqrt{\frac{D^3}{2cs}}. \quad (3)$$

Now, if the sun's mass were condensed into a point so that it would not be in the way of a body passing through it, then a body falling from the distance D would perform a double oscillation about the sun's centre in a time

$$T = 4t = \pi \sqrt{\frac{D^3}{2cs}}. \quad (4)$$

On the other hand, if ρ is the mean distance of a planet from the sun, the time such planet requires to perform a complete revolution around the sun will be

$$T_1 = 2\pi \sqrt{\frac{\rho^3}{cs}}. \quad (5)$$

Putting $D = 2\rho$, equation (4) becomes identical with equation (5); that is, will be $T = T_1$. Hence it follows the proposition:

"A body oscillating about the sun's centre with an amplitude of oscillation equal to twice the mean diameter of the orbit of a planet, will perform a double oscillation in the same time the planet performs a complete revolution around the sun."

The above two propositions are, to say the least, interesting, and exhibit the simplicity of the laws of nature.

THE WRITING TELEGRAPH.

By MR. W. E. GUMP.

[Read at the Stated Meeting of the FRANKLIN INSTITUTE, Wednesday, September 19, 1888.]

JOSEPH M. WILSON, President, in the Chair.

MR. GUMP: There has been no lack of *copying* telegraphs, commonly called autographic, which telegraph a copy of the writing or sketch submitted to them; but telegraphing *fac-simile* letters or characters while forming them with the stylus of the transmitter, so that they are reproduced by a receiving pen, was first made public by Mr. Edward Alfred Cowper, a well-known engineer of Great George Street, Westminster, England. The instruments were publicly exhibited by him at the meeting of the Society of Telegraph Engineers, on Wednesday, February 26, 1879, before one of those overflowing audiences which assemble there only on great occasions.

It has always seemed strange to me that this ingenious apparatus, which constituted the first real autographic telegraph, and at that time took rank with the brilliant series of telegraphic marvels, which from time to time engaged the attention of the world, has never been described in any of the many books on telegraphy which claim to give a history of the art from its conception to the present time. In these books you will find inventions of automatic and so-called autographic telegraphs duly recorded in order, and described in detail, but no mention whatever of the *only invention* which could properly be called *autographic*.

Doubtless it was due to this silence that this system did not sooner receive the attention of inventors, for Mr. Cowper surely pointed the way.

The principle which guided Mr. Cowper to a solution of the problem was that of "compounding the movements of a point in two directions, the one at an angle to the other, the actual movement of the point being the resultant of the two movements."

This principle Mr. Cowper has the honor of *first* applying

WHOLE No. VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.)

to a writing telegraph and, so far, it has proved the *only known* one of writing by telegraph.

Mr. Cowper effected this by employing two separate telegraphic circuits, each with its own wire, battery, sending and receiving apparatus. One of these circuits he made to transmit the up and down component writing of the pen's motion while the other simultaneously transmitted its side-long component.

Each continuously varying component was transmitted by causing the resistance of the circuit to vary with the component in question.

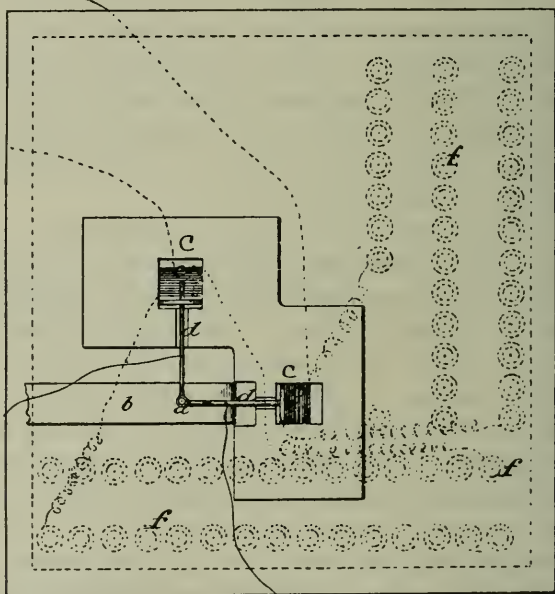


FIG. 1.

The diagrams illustrate the actual apparatus. *Fig. 1* is the plan of the sending instrument and *Fig. 2* an elevation of the same. *a* is the writing style which is held in the writer's hand in the ordinary way, while he shapes the letters one by one on paper pulled uniformly underneath by clock-work.

To *a* are attached two arms, *d d*, one for each circuit. Each arm, *d* (the one insulated from the other), is connected

to its particular battery, the other pole of said battery being connected to earth. Each arm, *d*, is fitted with a sliding contact at its free extremity, and as the stylus, *a*, is

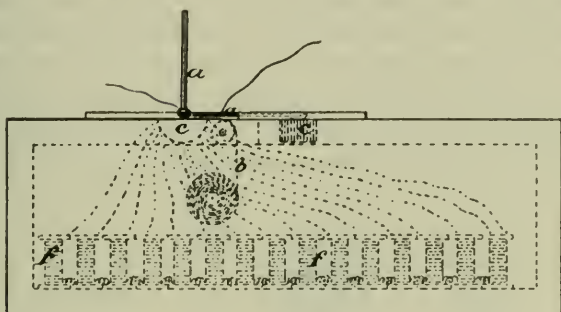


FIG. 2.

moved in writing, these contacts slide lengthwise across the edges of two series of thin metal contact plates. *c c*, insulated from each other.

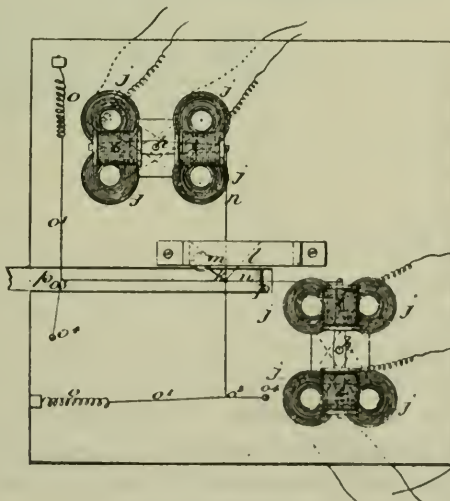


FIG. 3.

Connected between each pair of these plates, there is a resistance coil *f*, and the last of these is connected through the last plate to the line wire. As *d* slides outward across the plates, the current from the battery has to pass through fewer coils, since *d* short circuits a number of coils pro-

portional to its motion, and the fewer of these resistance coils in circuit, the stronger will be the current in the line. If the stylus or pencil makes a large stroke, there will be a strong current sent in the line, if a short one, there will be a weak one, and thus they are varied to strong or weak in accordance with the varied movements of the pencil *a*.

Fig. 3 is a plan of the receiving instrument, and *Fig. 4* the elevation of the same. *h h* are light pivoted needles, surrounded by coils of fine insulated copper wire, *i i*, and controlled in their zero position by the electro-magnets *j j j j*, placed underneath, the whole forming a pair of galvanoscopes or current detectors, one for each line. The line wires pass through the coils *i i* to earth. The writing pen *k*

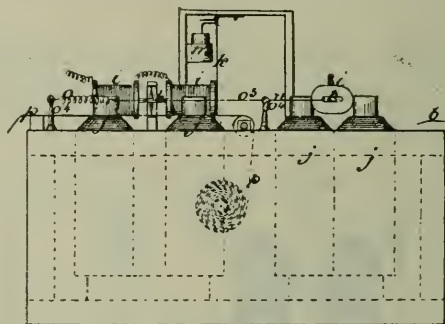


FIG. 4.

is connected to the nearest tip of the needle of each galvanoscope by threads *n n*, which are kept taut by the fibres *o₁ o₂ o₃*, the springs *o* and the pins *o₄*. Now, since the needles deflect in proportion to the strength of the current flowing through its coil, the points of these two needles keep moving with the varying currents. But since the motions of the sending pen vary these currents, the receiving pen, controlled by the united movements of the needles, will trace out a close copy of the original writing.

The electro-magnets *j j j j* were magnetized by a local battery. Permanent magnets would have been a gain in simplicity, Mr. Cowper mentions this in his patent. The next improvement Mr. Cowper submitted to the public was in making the movements of the style or pen reproduce

greater or less strength of current by bringing into the circuit a greater or less number of battery cells. By still another method, he effected the variation in the strength of currents by combining various numbers of battery cells with various resistances. The contact bars at right angles to each other and worked by the sending pen, were made to slide in guides and have two projections on their under side, one sliding over a set of contact plates connected to the resistance coils, and the other projection sliding over a set

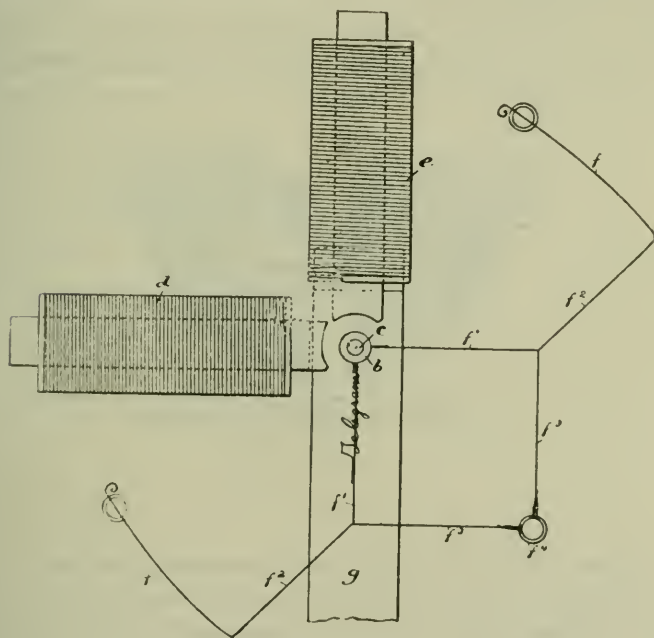


FIG. 5.

of contact plates connected to the battery cells, so that as the operator would write, battery cells were added, and resistance coils left out of the circuit when greater power was wanted, or battery cells were left out and resistance coils taken into the circuit when less power was required.

His receiver was changed to that of a single movable soft iron bar or needle, to which the pen was connected, suspended before two fixed electro-magnets situated at right angles to each other, through the coils of which elec-

tro-magnets, the varying currents of the two circuits were made to pass.

Another plan was by pivoting or suspending the pen itself, and having fixed on it a piece of soft iron exposed to the varying attraction of the electro-magnets in the two directions, acting in opposition to springs, pulling it in opposite directions. The pen used was a siphon pen, the shorter leg of which dipped into an ink reservoir.

The arrangement of the electro-magnets and springs are shown in *Fig. 5*.

The pen fits in the central hole of the disc *b*. This disc is of soft iron, and acts as an armature to both electro-magnets, *d e*, placed at right angles to each other. *f f* are the

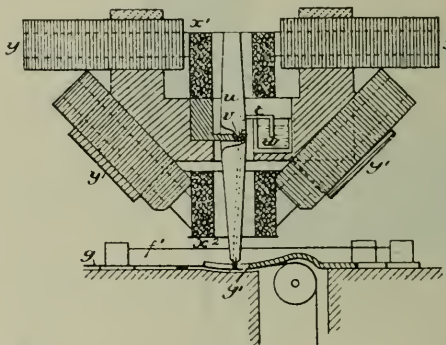


FIG. 6.

fine springs which supply the necessary resistance to the pen against the pull of the magnets, the pen being connected to those springs by the threads $f^1 f^1 f^2 f^2 f^3 f^3$, the last two of which are attached to the post f^4 . The paper *g* upon which the message is written by the siphon pen, was moved by clock mechanism.

Mr. Cowper shows various modifications of armatures and pen attachments. Another style of his receivers is shown in *Fig. 6*. You will observe as he progressed that each was less delicate. In this receiver the armature *u* was a bar of soft iron of a tubular section. This armature he called the needle. It held the siphon pen *t*, which had its longer leg passed in through a hole in the

side of the needle, and projected out through another hole at the lower extremity of the same. The shorter leg of the siphon dipped into the ink reservoir *W*. The needle armature was supported by a fixed bracket *V*. This bracket projected into the interior of the needle, and at its extremity supported the needle from a steel point, which was fixed in the axis of the needle. The side of the needle where the bracket entered was cut away, so that the needle when thus supported was free to move in any direction. Stationary coils of wire $X^1 X^2$ surrounded the needle, one at each end. These coils were of sufficient internal diameter to permit the required movement of the needle, and kept the needle constantly magnetized by means of a local battery with which they were connected. The set of stationary electromagnets, $y y^1 y^1$, were placed in circuit with one of the line wires, and consequently always acted together.

Their poles were so arranged that when the needle was polarized, they all united to deflect it to an inclined position, in the same plane in which they were placed. There was a similar set of magnets connected to the other line wire, and precisely similar in their arrangement and action, which were placed in a plane at right angles to the plane of the set described. Springs and threads similar to those shown in *Fig. 5* were used to give the necessary resistance to the needle against the pull of the magnets. The pen as stated was pivoted and in order that it could more easily traverse the surface of the paper, the paper where the pen moved over it was given a concave form corresponding to the arc in which the pen moved, by passing the paper under a bent form with a hole through it of sufficient size to allow of the largest movements of the pen.

A different device had for its object, the raising of the receiving pen from the paper when the operator ceased to write. This was done by attaching the pen support, by means of a thread, to a spring controlled by an electromagnet, through the coils of which one of the circuit currents was made to pass. While writing, the thread hung inoperative, but when the currents were caused to cease by raising the sending pen on the completion of the word or

character transmitted, the spring released by the magnet raised the pen out of contact with the paper, thus causing each word to be written separate from the other, as in ordinary writing. There are different ways mentioned by Mr. Cowper for accomplishing this same object. It may interest my hearers to know that among his claims for a patent, Mr. Cowper broadly covers "the combination with a receiving pen of means for lifting the same from the paper when the circuit is broken." The patents of Mr. Cowper also broadly cover the method of writing by means of a varied current. These patents were purchased by the Writing Telegraph Company, of New York.

The writing reproduced on the instruments of Mr. Cowper was of a slightly nervous, tremulous character, but "not sufficiently marked to prevent the handwriting of the person at the transmitting instrument from being readily recognized." The instruments were operated successfully over a ninety mile circuit. They were expensive, could scarcely write twenty words a minute, were delicate in many parts, the contacts were liable to corrode and there were many things to perfect to make it practicable for commercial use.

Mr. J. Hart Robertson next appears in this line of invention. Familiar with many of his experiments and assisted by data furnished by him to the Writing Telegraph Company, I am enabled to state the most prominent of his experiments and devices, which stand as mile posts on the inventive road to a successful writing telegraph instrument. It is but just to Mr. Robertson to state that when he first devised his writing telegraph, he was not aware that Mr. Cowper had ever made any invention of the kind. Mr. Robertson necessarily operated on the same principle of "compounding a point in two directions, the one at an angle to the other," as demonstrated by Mr. Cowper, but the devices for accomplishing the work began far in advance of where Mr. Cowper permitted his experiments to end. Not that his results were obtained at once for, in reality, they were the outcome of experiments, the majority of which were very discouraging. Mr. Robertson's first transmitter

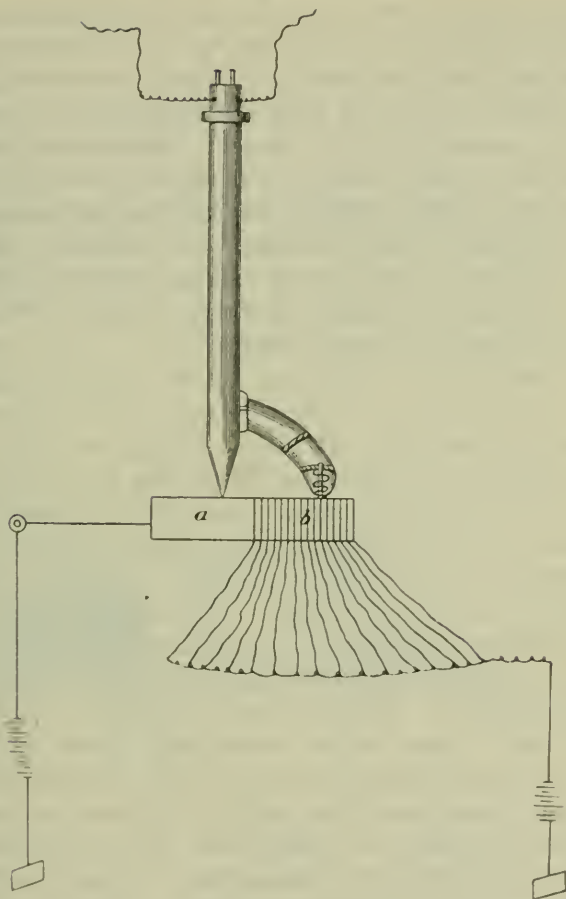


FIG. 7. Elevation.

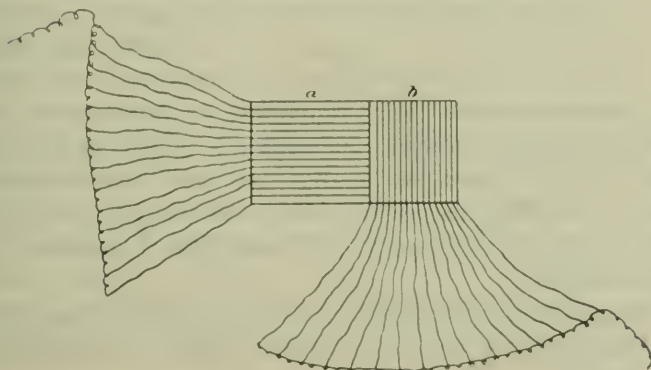


FIG. 7. Plan View of Contacts.

consisted of two sets of metal contact plates placed at right angles to each other as shown in *Fig. 7*. These plates were insulated one from the other and connected electrically by means of wires connected with resistance coils. Instead of the sliding contacts of Mr. Cowper's instrument, the stylus acted as the contact maker as it moved over the contact plates when writing. This stylus had two points, one passing over strips *a*, and the other over strips *b*. The two points of the stylus had springs so as to allow a free movement of the hand, without breaking contact between the stylus points and the metal strips.

The battery was conducted to the contact points by means of flexible wires attached to the top of the stylus and passing through it. It will be readily seen that as letters are formed on the contact slips, the two currents are varied, and their varying movements thus actuate the properly constructed receiver and cause its pen to reproduce the movements of the transmitting stylus. It is not expedient to illustrate the remaining parts of this instrument at this time. Sufficient to state, that it was designed to write on stationary paper, which moved or not, as was desired, when the pen was lifted. The pen could be lifted to cross the *t*'s and dot the *i*'s, the writer controlling these movements through his transmitting stylus, as well as feeding the paper forward or upward a certain definite distance as required. The action of lifting or laying down the stylus, also automatically connected the transmitter or not, as the case might be. The receiver was always in circuit. The lines for the receiving pen had to be short, owing to the fact that the further the writing extended to the right, the more it would be up hill and the letters be distorted accordingly. Mr. Robertson states that this defect is inherent in every writing telegraph receiver in which a single point is fulcrumed to two others at an angle to each other, and thus makes it impossible to reproduce writing on stationary paper in lines of any length, without thus distorting it to a certain extent.

It is partially remedied by increasing the distance of the fulcrumed point from the two others sufficient to allow of a larger radius.

Sometime afterwards, however, he got over the difficulty by fastening the magnet that gave the movement in one direction, together with its complete adjusting device, on the armature of the magnet that gave the movement at right angles to the first.

By this means writing can be produced in lines on stationary paper without being distorted and in an exactly straight line, as the two connecting levers can always move at right angles to each other, no matter in what part of the field the writing takes place. While the writing on this instrument was a fair reproduction, Mr. Robertson was

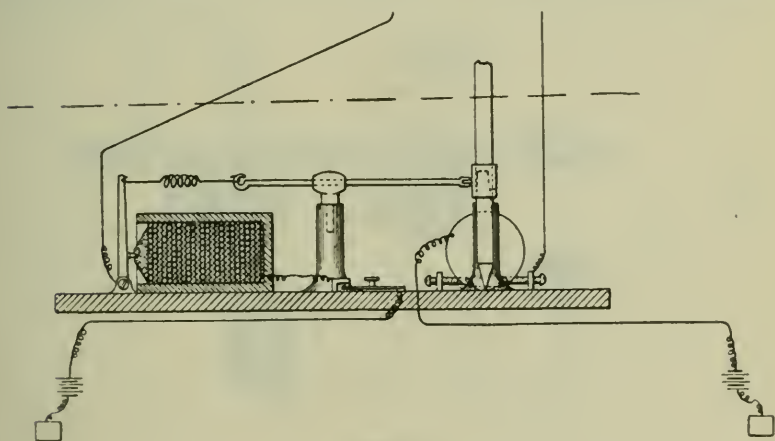


FIG. 8.

not satisfied with its "irregular or wavy character," which he termed "jerky."

This he expected to remove by a proper adjustment of contacts and resistances.

The instrument was not as simple as he wished and Mr. Robertson avoids any complex mechanism. About this time he learned of Mr. Cowper's invention, which caused him to seek a varying movement, more gradual than by "step by step." Care was taken to protect the invention as it had proceeded. His researches showing the great and gradual range of resistance obtained by pressing pieces of carbon together, he soon invented his first carbon transmitter.

This transmitter had forty carbon discs (*Fig. 8*) one-half inch in diameter and one-fortieth of an inch thick in each series, which were placed at right angles to each other. A screw follower was afterwards added on each cylinder which contained the discs, which served to bring the discs in better contact and which allowed the maximum resistance proportional to that of the line to be quickly adjusted. It seems needless to add that the pressure on these series of discs produced by the stylus in writing took the place of the contacts with their resistance coils and gave Mr. Robertson the gradual variation he sought. The first

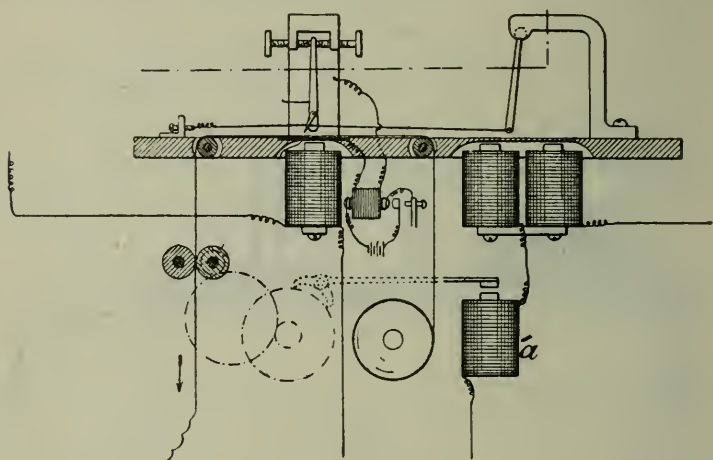


FIG. 9.

receiver constructed by Mr. Robertson to work with this transmitter was constructed as shown in *Fig. 9*. It consisted of two magnets fastened under the base and at an angle to each other. Above each was freely suspended a very light, soft iron armature. One was influenced by what we term the "up and down" and the other by the "right and left" magnet. A pen carrier was pivoted to the former and partook of an "up and down" motion from it. The right and left motion it got from the other armature to which it was connected by a silk fibre.

The armatures were suspended from permanent magnets, which gave enough polarity to them to be repelled by like

poles of the electro-magnets, and attracted by the opposite, the object being to get as large a movement as possible. It was found that the movement was at the expense of power and speed, and the friction on the trunnions working at right angles to each other was objectionable for rapid writing.

The pen was a small tube of aluminium, weighing only two grains. This proved too great a friction on the paper and the idea of a pen and ink reproduction with this receiver was given up for a different plan of writing with it. A light platinum-pointed needle was used for a writing stylus and was suspended so that the point was about one-thirty-second

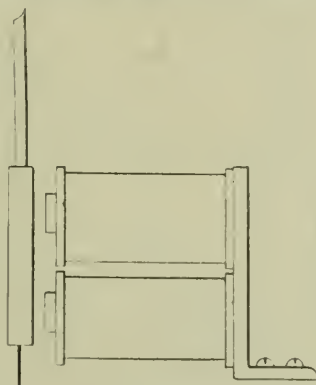


FIG. 10.

of an inch above the paper which moved beneath it. One end of the secondary wire of a local induction coil was connected to this needle and the other end was fastened to a metal plate over which the paper moved. As the needle reproduced the movements of the writing stylus, the induced current from the needle to the contact plate discolored the paper on its passage through it. The magnet *a* was used to control the movement of the paper. The paper was made to start or stop at the option of the writer. The words could be disconnected and the t's crossed by automatically cutting the induction coil out or into the circuit. The paper was a dry chemical paper. It took several weeks of experimenting before one could be ob-

tained which would discolor, without having the stylus in absolute contact with it, or without moistening the paper. The reproduction was excellent, but in the course of a couple of weeks would all fade, and this was considered fatal. The next receiver is shown in *Fig. 10*. It consisted of a piece of soft iron, about three and one-half inches long and one-quarter of an inch square, supported on a steel rod and acting as a combined armature for both sets of magnets, placed at right angles to each other. This was a more powerful receiver.

The weight of the armature being relatively great as compared with that of the fountain pen filled with ink and

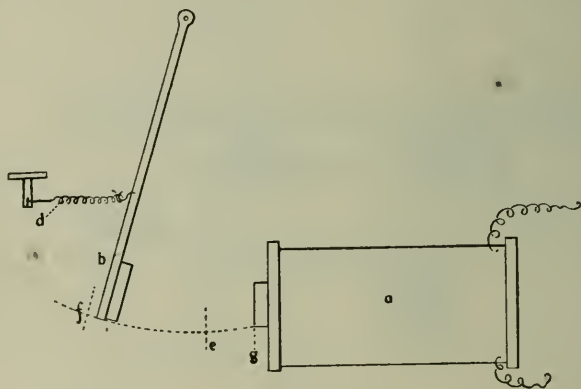


FIG. 11.

pivoted at the upper end of the rod, made the motion of the receiving stylus more easily controlled. Thus one improvement led to another. On this receiver the reproduction of an "up and down" or "right and left" movement was perfect. The writing, except for its "wavy character," was a good reproduction; but when it came to the full reproduction of an angle between the two movements $\backslash$, only half of the line could be made. Mr. Robertson attributed this to the "magnetic lines of force," conflicting with and partially neutralizing each other when the armature was in a certain position, and from that sprang his idea of two armatures, magnetically insulated and pivoted on the same rod.

There were yet two defects to be overcome. One Mr.

Robertson termed "eliminating the jumping point of the armature." This is explained in *Fig. 11*. As the strength of a magnet is gradually increased, the armature will also be gradually and evenly attracted until it reaches a certain distance from the magnet, as shown by the letter *e*, when its speed will increase in a much greater ratio than from *f* to *e*. Many expedients were tried to overcome this and utilize the space between *e* and *g*, but it was only by detracting from some other feature. The other defect alluded to, was the tremulous "wavy character" of the writing. He sought to overcome both difficulties by constructing his armature, as shown in *Fig. 12*, to pull downward as well as toward the poles of the magnet. Although

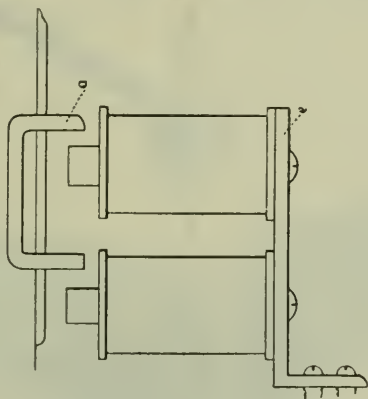


FIG. 12.

there was power lost by this downward pull it was more than compensated for by the steadier action gained. There was still a trembling of the receiver rod at the slightest jar or vibration, and if the operator did not have a very steady hand, the writing would show it very decidedly. A very simple but very important improvement removed this final defect. This improvement was simply immersing the armature or its extension in a vessel containing a liquid.

The first trial made was with the single armature, which moved in a cup of mercury, and although the amplitude of the movement of the armature was small, owing to the large body of mercury used, the improvement was so apparent that experiments were continued.

The result was the adoption of a light inverted thimble, made of German-silver and attached to the armature rod in such manner that it could float in a cup of glycerine. This removed every vestige of the tremor in the writing and made every mark clear and distinct. With the advent of the liquid cup, the fact was demonstrated that almost any kind of armature gave good results, in combination with it, and that if it had been used at the start a great deal of time spent in experimenting would have been saved.

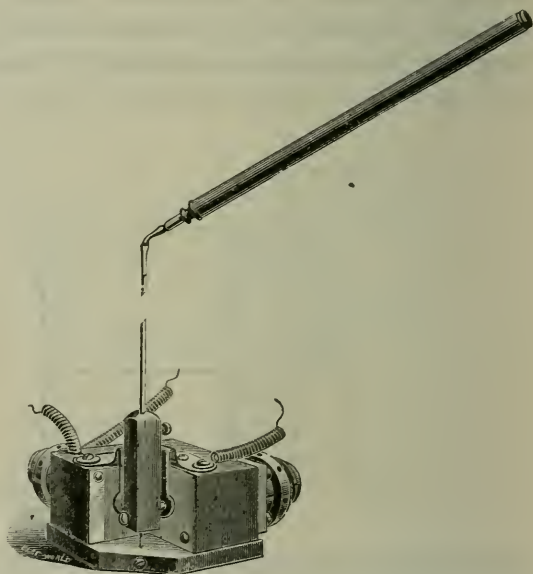


FIG. 13.

From this point progress was more rapid, and we now have instruments which reproduce the writing so accurately, that the paper containing the original must be marked to distinguish it from the reproduction.

The present transmitter (*Fig. 13*) consists of two series of thin carbon discs about one-half inch in diameter, placed at right angles to each other, in a hard rubber receptacle. The normal pressure of each series of discs is adjusted by a screw. The stylus rod has insulated pressure points opposite the piles of discs, and is supported at the base on

thin wire, so that by taking hold of the handle it can be manipulated, as in writing, and in so doing the pressure points are pressed against springs which press upon the carbon discs, and thus vary the current.

Each of these series of carbon discs is in circuit with one of the line wires which are led to the receiver.

The present receiver (*Fig. 14*) consists of two pairs of electro-magnets, each in circuit with one of the line wires and placed at right angles to each other. The rod which

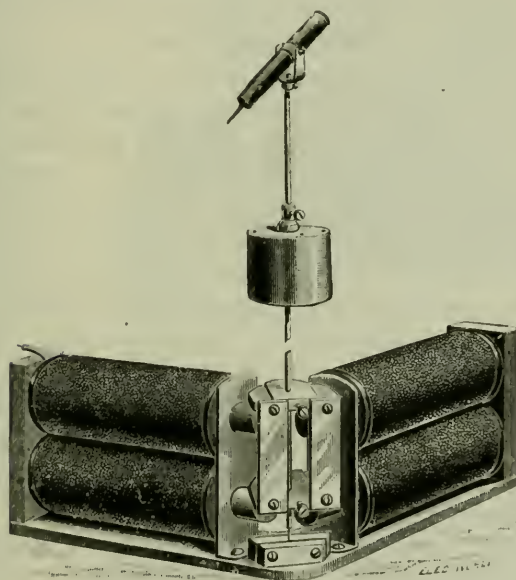


FIG. 14.

carries the pen and the armature has a spring wire projection at its base, and is fastened at a point where the poles would meet if extended. The armatures for each pair of magnets have a brass connection and are placed above the cores of the magnets.

The armature rod carries the inverted thimble, which floats in the glycerine, and also extends above the top of the case and carries the fountain pen.

The armatures respond to the attraction of the electro-magnets, as they are actuated by the varied currents sent

into the lines while writing, and cause the receiving pen to reproduce each letter as fast as made at the transmitter.

The transmitter and receiver are placed in a case about 14 inches long, 9 inches wide, and 8 inches deep. This case (*Fig. 15*) also contains a bell and the mechanism which moves the strip of paper. Above the box appears the handle of the transmitting stylus and the armature rod carrying the pen.

The switch shown on the left for changing the current from the transmitter to the receiver has been dispensed with, and this work is done automatically.

Mr. Robertson also made transmitters which varied the current while writing by immersing electrodes more or less in liquid. Fine carbon spirals, specially prepared by him, were also tried and gave fair results. A comparatively small carbon spiral will give all the resistance necessary; a carbon spiral of five convolutions, about one and two-thirds inches in diameter, gave a minimum resistance of four and one-half ohms when pressed together in writing, and 145 ohms when the convolutions were not in contact. The carbon was $\frac{1}{8}$ of an inch wide and $\frac{1}{37}$ of an inch thick.

Our company had a great deal of trouble in obtaining uniform carbon. Whether sawed from carbon rods and then rubbed down, or moulded in discs and then finished, there was a great variation in their resistance.

Carbon discs, one-half inch in diameter and .05 of an inch in thickness, after carefully smoothing off each surface and placing some thirty of them in a superficial contact under a pressure of fifteen pounds, would give a total resistance of hundreds of ohms and every lot would greatly vary.

Under these conditions sufficient difference of resistance could not be obtained to operate all instruments alike.

Mr. Harry Etheridge, a young electrician of great promise, was given the problem to solve, and instructed to make each transmitter uniform. Each carbon disc was taken separately, subjected to a constant pressure and its resistance obtained. The pressure was applied superficially and equalled about eight pounds. Under this pressure some discs would show 1 ohm, another .6 ohm, another 2, another 15 ohms, and so

on, many reaching the extraordinary amount of 800 ohms. From this data it was readily seen why thirty discs, taken

any number of stocks

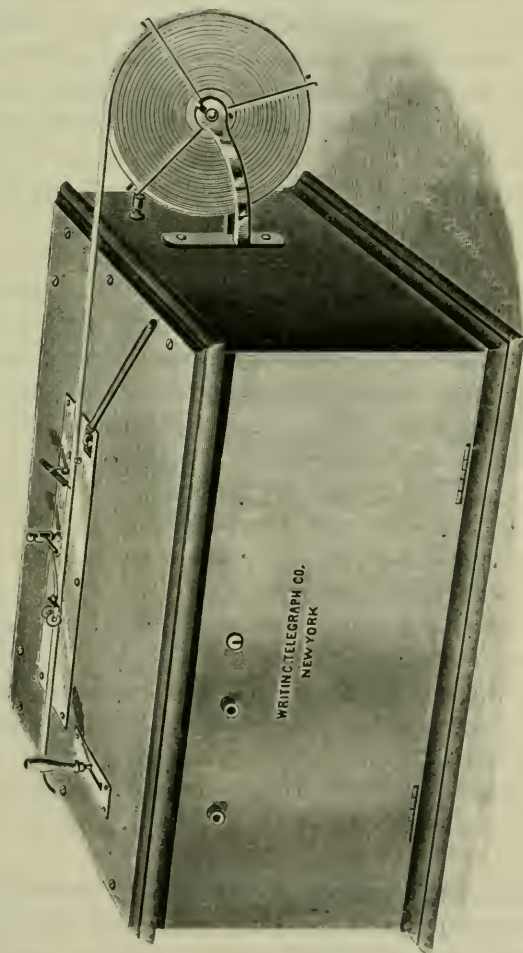


FIG. 15.

at random and arranged in series, varied so much in resistance. With care and experience in preparing carbons, they are now all made of low resistance, the majority less than

.2 of an ohm, and none are used above that resistance. In this way our transmitters at Pittsburgh are adjusted to a minimum resistance of five ohms and a maximum of 150 ohms.

Guided by these measurements of resistances in carbons and their resistance as the stylus rod is pressed against them in every movement of about one-twentieth of an inch or less, Mr. Etheridge became convinced that he could construct a transmitter without carbon, which would always prove constant. Several made by him proved failures, but perseverance and the benefit of experience at last succeeded. The Etheridge transmitter bids fair to earn a prominent rank among writing telegraph transmitters. The stylus is arranged to press against a series of steel tongues arranged in a vertical position, and to each of which is connected a suitable resistance. The upper ends of these tongues are tipped with platinum and as they are compressed and expanded, the resistances are thus "cut in" or "cut out," respectively. The resistances are composed of German-silver wire. It is a combination of the Robertson and Cowper systems and does perfect work.

It is due Mr. Etheridge to state that it is by his improvement to our exchange instruments, that we are enabled to record a message on any subscriber's instrument, whether that subscriber is present or not.

The writing telegraph is yet in its infancy, and we all have much to learn about it.

While our company has not confined itself to only one style of instrument, it considers the instrument it has perfected to be the most simple and practical for commercial use.

The field for a writing telegraph is a large one, and its many uses are so apparent it is not necessary to repeat them here.

At our experimental exchange at Pittsburgh we have had the instruments in constant operation throughout the year. Through the winter's storms and the summer's heat the instrument has demonstrated its commercial practicability. A locomotive puffs with heavily loaded freight trains past our exchange, but fortunately the pen writes indifferent to

any noise. We use poles in conjunction with the Electric Light Company, immaterial as to whether our wires are above, below, or surrounded by theirs. The pen writes just the same in utter ignorance of the word induction.

For six months we have had instruments in daily use in several cities, reporting base ball scores by innings. This has been so satisfactory that we are arranging to greatly enlarge the field for the coming year.

We are past the experimental stage: are ready for, and are doing, a practical commercial business, and our company anticipates a bright future for the writing telegraph.

GENERAL THEORY OF JOINTED BOW GIRDERS.

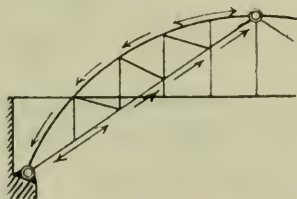
BY E. A. WERNER, C.E.

(Concluded from Vol. cxxvi, page 63.)

STRAINS T OF THE UPPER CORD.

The course of the ties corresponding to the maximal and minimal loadings, is as follows:

Full load.
No load.



hence the numeric maximal and minimal values of T .

MAXIMA.

$$T_1 = \frac{139,600}{0.537} = 261,000 \text{ lbs.} \quad T_2 = \frac{172,900}{0.759} = 228,000 \text{ lbs.}$$

$$T_3 = \frac{198,800}{0.885} = 225,000 \text{ lbs.} \quad T_4 = \frac{219,800}{0.960} = 230,000 \text{ lbs.}$$

$$T_5 = \frac{219,800}{0.995} = 222,000 \text{ lbs.}$$

MINIMA.

$$T_1 = \frac{39,800}{0.537} = 72,000 \text{ lbs.} \quad T_2 = \frac{49,400}{0.759} = 64,000 \text{ lbs.}$$

$$T_3 = \frac{56,800}{0.885} = 63,000 \text{ lbs.} \quad T_4 = \frac{62,800}{0.960} = 62,000 \text{ lbs.}$$

$$T_5 = \frac{62,800}{0.995} = 62,000 \text{ lbs.}$$

STRAINS N OF THE TIES.

We have :

$$W = N \cos \alpha,$$

thus

$$\text{Maxima} = N'$$

$$N_{II} = \frac{48,400}{0.973} = 50,000 \text{ lbs.}$$

$$N_{III} = \frac{43,300}{0.919} = 48,000 \text{ lbs.}$$

$$N_{IV} = \frac{40,300}{0.961} = 42,000 \text{ lbs.}$$

$$\text{Minima} = N''$$

$$N_{II} = \frac{5,700}{0.494} = 12,000 \text{ lbs.}$$

$$N_{III} = \frac{9,900}{0.526} = 19,000 \text{ lbs.}$$

$$N_{IV} = \frac{13,400}{0.627} = 22,000 \text{ lbs.}$$

$$W = 0$$

The general equations of W show, that only *two* members are to be considered, of which the first one always is negative, the second one positive.

It follows thus easily :

W_{II} The only position of the loads producing a negative W_{II} is a loading from 1 — 1. It corresponds to a relative maximum of U , as W_{III} is positive at the same time.

W_{III} The only position of the loads creating a negative W_{III} is 1 — 2, involving a positive W_{II} at the same time.

W_{IV} The only position of the loads making W_{IV} negative and W_{III} positive at the same time is 1 — 3.

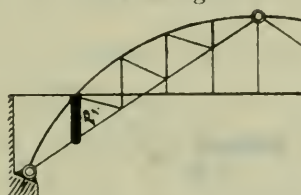
W_{IV} becomes furthermore negative for a loading 1 — 2, but W_{III} is then *not* positive.

STRAINS OF THE POSTS.

P_1

The *lower* chord has to be taken into consideration.

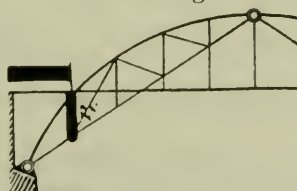
W'' acting.



As long as W_{II}' is acting the lower end of P_1 which is into consideration, will have no tie, thus:

$$P_1 = 0$$

W''' acting.



We know from $W' = 0$, that the only position of the loads giving W_{II}'' corresponds to a loading 1 — 1. It is thus:

$$P_1 = W_{II}'' (\tan \alpha_{II}'' + \tan \gamma) = 5,700 \cdot 1.093 = 6,200 \text{ lbs.}$$

$W = 0$ acting.

This case is included in W'' and W''' .

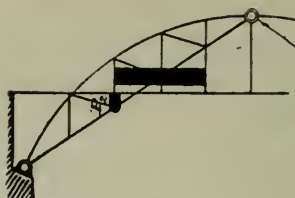
P_2 LOWER PART.

The *lower* chord is to be taken into consideration.

W' acting.

It is:

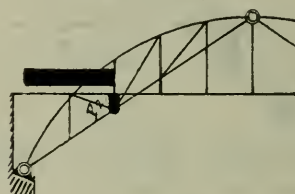
$$P_2 = W_{II}' \tan \alpha_{II}' + [U_2 - U_1] \tan \gamma = W_{II}' (\tan \alpha_{II}' + \tan \gamma)$$



Hence P_2 is a maxima with W_{II}' and the numeric value will be :

$$P_2 = 48,500 \times 0.9026 = 43,800 \text{ lbs. (compression.)}$$

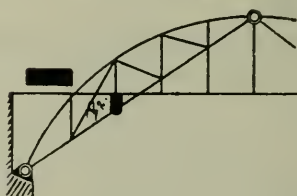
W'' acting.



We know, that the only position of the loads giving W_{III}'' corresponds to a loading 1 — 2. W_{II}' is then positive at the same time and it will thus be :

$$P_2 = U_2 (\tan \mu_{III} - \tan \mu_{II}) + g = -41,200 + 63,000 = 21,800 \text{ lbs. (compression.)}$$

$W = 0$ acting.

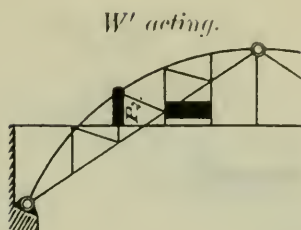


To have the lower end of P_2 free of the action of ties, W_{II}'' and W_{III}' must act. This corresponds to a loading 1 — 1 and the numeric value is then :

$$P_2 = 0$$

P_2 UPPER PART.

The *upper* chord is to be taken into consideration.



There is :

$$P_2 = W_{III}' \tan \alpha_{III}' + U_3 \tan \mu_{III} - U_2 \tan \mu_{II}$$

or :

$$U \tan \mu_{III} = 0.01470 G_1 g_1 + G_2 (1.6536 - 0.02204 g_2)$$

$$U_2 \tan \mu_{II} = \frac{0.03136 G_1 g_1 + G_2 (1.5677 - 0.02090 g_2)}{-0.01666 G_1 g_1 + G_2 (0.0859 - 0.00114 g_2)}$$

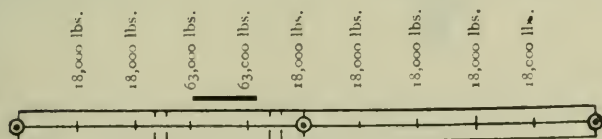
$$W_{III}' \tan \alpha_{III}' = -0.00364 G_1 g_1 + G_2 (0.5659 - 0.00754 g_2)$$

$$P_2 = -0.02030 G_1 g_1 + G_2 (0.6518 - 0.00868 g_2)$$

from this follows the maximum line of G_2

$$p_2 = \frac{65,180}{868} = 75.1 \dots ft.$$

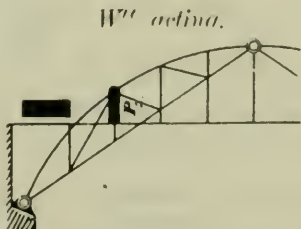
and with it, the position of the loads creating the maximum of P_2 :



and the numeric value :

$$P_2 = -0.0203 \times 810,000 + 126,000 \times 0.1961 = 8,300 \text{ lbs.}$$

(compression.)



The only position of the loads producing W_{II}'' is 1 — 1, with a positive W_{III}' at the same time.

Hence :

$$P_2 = 18,000 \text{ lbs.}$$

$$W = 0 \text{ acting.}$$



The only position of the loads giving W_{III}'' is 1 — 2, with a positive W_{II} at the same time.

Hence :

$$P_2 = U_2 (\text{tng } \mu_{III} - \text{tng } \mu_{II}) = -41,200 \text{ lbs. (tension.)}$$

$$P_3$$

The *upper* chord is to be taken into consideration.

$$W' \text{ acting.}$$



We have :

$$P_3 = W_{IV}' \text{tng } \alpha_{IV}' + U_4 \text{tng } \mu_{IV} - U_3 \text{tng } \mu_{III},$$

or, as U_3 and U_4 are made up of the same factors :

$$\begin{aligned} P_3 &= W_{IV}' \text{tng } \alpha_{IV}' + U_4 \text{tng } \mu_{IV} + U_3 \text{tng } \mu_{IV} - U_3 \text{tng } \mu_{IV} - \\ &\quad - U_3 \text{tng } \mu_{III} = P_3 = W_{IV}' \text{tng } \alpha_{IV}' + (U_4 - U_3) \text{tng } \mu_{IV} + \\ &\quad + U_3 (\text{tng } \mu_{IV} - \text{tng } \mu_{III}) = W_{IV}' (\text{tng } \alpha_{IV}' + \text{tng } \mu_{IV}) - \\ &\quad - U_3 (\text{tng } \mu_{III} - \text{tng } \mu_{IV}) \end{aligned}$$

$$W_{IV}' (\text{tng } \alpha_{IV}' + \text{tng } \mu_{IV}) = -0.00275 G_1 g_1 + G_2 (2.1894 - 0.0219 g_2)$$

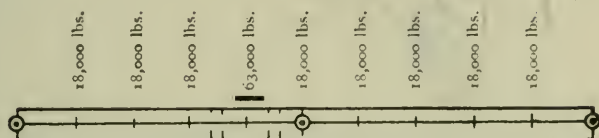
$$U_3 (\text{tng } \mu_{III} - \text{tng } \mu_{IV}) = +0.00659 G_1 g_1 + G_2 (0.7416 - 0.00989 g_2)$$

$$P_2 = -0.00934 G_1 g_1 + G_2 (1.4478 - 0.01930 g_2)$$

From it follows the maximum line of G_2 ,

$$p_3 = \frac{14,478}{193} = 75.1 \dots ft.$$

and the position of the loads inducing the maximal value of P_3 .



from which we derive the numeric value :

$$P_3 = -1,620,000 \times 0.0934 + 63,000 \times 0.2898 = 3,100 \text{ lbs.} \\ (\text{compression.})$$

W''' acting.



The only position of the loads inducing W_{III}'' is 1 — 2, with positive W_{IV}' . Hence the value of

$$P_3 = 18,000 \text{ lbs. (tens.)}$$

$W'' = 0$ acting.

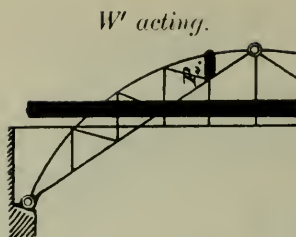


The position of the loads inducing a W_{IV}'' and a W_{III}' is a loading from 1 — 3. The numeric value of P_3 is then :

$$P_3 = U_3 (\tan \mu_{IV} - \tan \mu_{III}) = 170,300 \times 0.2346 = 40,000 \text{ lbs.} \\ (\text{tension.})$$

P_4

The *upper* chord is to be taken into consideration.

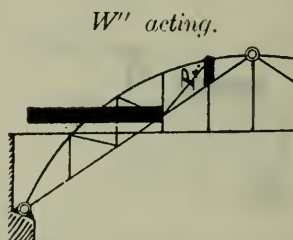


There is, as $N_V = 0$;

$$P_4 = U_1 (\tan \mu_{IV} - \tan \mu_V)$$

Hence P_4 is a maximum with U_1 or for full loaded girder and the numeric value will be:

$$P_4 = 219,800 \times 0.196 = 43,100 \text{ lbs. (tension.)}$$



The *two* positions of the loads inducing W_{IV}'' are 1-2 and 1-3. In both cases, the numeric value of P_4 will be:

$$P_4 = 18,000 \text{ lbs. (tension.)}$$

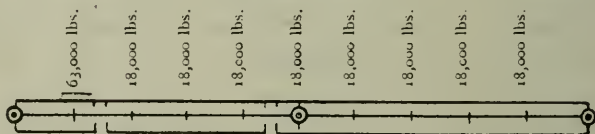
$$W = 0 \text{ acting.}$$

This case is included in W' and W'' .

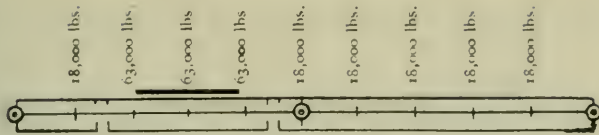
With this it is now possible to compute the absolute maximal and minimal values of P .

We have :

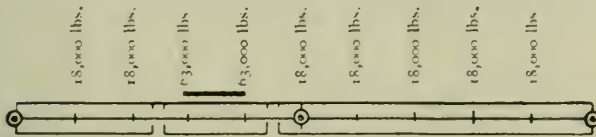
MAXIMA.



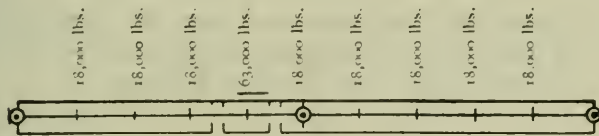
$$P_1 = 6,200 \text{ lbs. compression.}$$



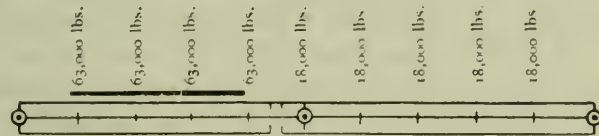
P_2 lower part = 43,800 lbs. compression.



P_2 upper part = 8,300 lbs. compression.

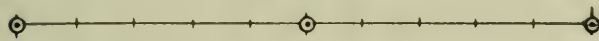


P_3 = 3,100 lbs. compression.

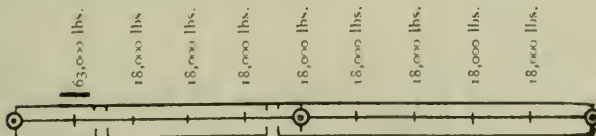


P_4 = 43,100 lbs. tension.

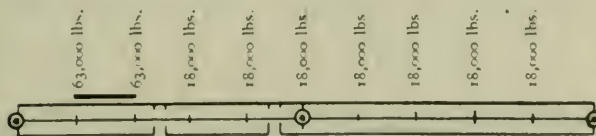
MINIMA.



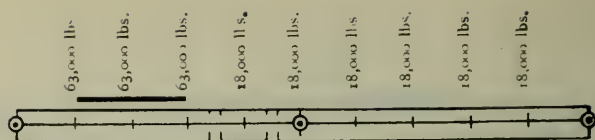
P_1 = 0.



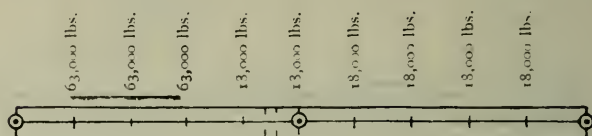
P_2 lower part = 0.



P_2 upper part = 41,200 tension.



$$P_3 = 40,000 \text{ tension.}$$



$$P_4 = 18,000 \text{ tension.}$$

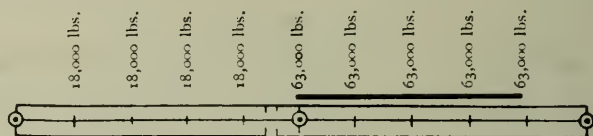
Check.—Calculate the values of P from the end of the post not used in the above calculation, with the same positions of the loads. The same values must be found as above.

As U , W , P , have only two members in G_1 and G_2 , these stresses are independent of the loading of the part corresponding to G_3 .

I will illustrate this with one example for each stress.

$U_4 \text{ min.}$ is generated when the grider is completely empty.

I will suppose now, that the half bow corresponding to G_3 , be also loaded, thus :

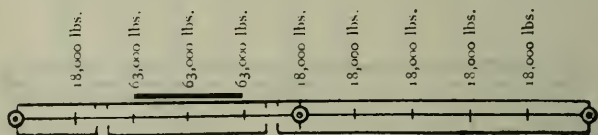


We have then :

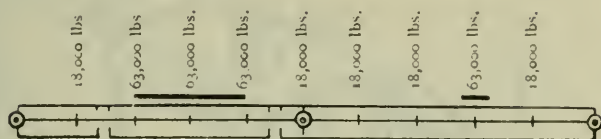
$$U_4 = H - \left(\frac{M}{h} \right)_1 = 168,800 - 106,000 = 62,800 \text{ lbs.}$$

The same value, which we have found, with an empty grider.

$W_{11} \text{ maximum.}$ The loading for it is, as we have seen :



I will now suppose, that the fourth panel point of G_3 be loaded also, thus :

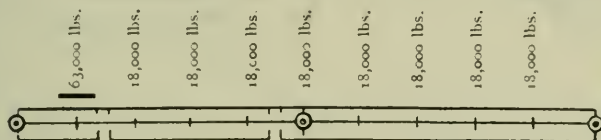


We have then :

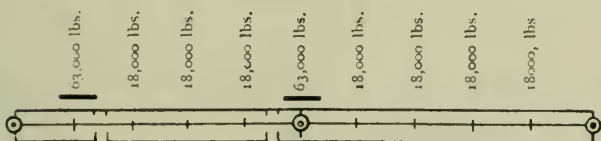
$$W_{11} = \left(\frac{M}{h}\right)_2 - \left(\frac{M}{h}\right)_1 = + 7,300 - (-42,100) = + 48,400 \text{ lbs.}$$

the same value found with empty right half bow.

P_1 maximum. The position of the loads corresponding to it, is :



I will now suppose, that the top joint be loaded in addition, thus :



We have then :

$$P_1 = W_{11}'' (\text{tang } \alpha_{11}'' + \text{tang } \gamma) \text{ and it is :}$$

$$\begin{aligned} W_{11}'' &= \left(\frac{M}{h}\right)_2 - \left(\frac{M}{h}\right)_1 = -33,900 - (-28,200) = \\ &= -5,700 \text{ lbs.} = 5,700 \text{ compression.} \end{aligned}$$

hence :

$$P_1 = 5,700 \times 1.093 = 6,200 \text{ lbs.}$$

the same value, we have found with empty G_3 .

Computing finally the maximal and minimal strains obtained in the previous calculations, we have the following strain sheet :

In *Figs. 8, 10, 12, 14, 16*, the abscissa g_m is omitted in the lower part of the figures.

In *Fig. 9*, $g_{m1}, g_{m2}, g_{m3}, g_{m4}$, is omitted in the upper part of the figure.

In *Figs. 18, 19*, g_s is omitted in the lower part of the figure.

In Part II, correct :

Page 491, line 16 from bottom, *read*—

$$\Sigma (Y), \text{ instead of } \Sigma (H)$$

Page 493, line 13 from bottom, *read*—

$$T_m \cos \beta_m = \tau_m \cos \beta_m + H, \text{ instead of } T_m = \tau_m \pm H.$$

Page 494, line 5 from top, *read*—

$$T_m \cos \beta_m = \mp \left(\frac{M}{h} \right)_m \pm H, \text{ instead of } T_m = \mp \left(\frac{M}{h} \right)_m \pm H.$$

Page 55, lines 17 and 18 from bottom, *read*—

“lines of the loads,” instead of “lines of the forces.”

Page 56, line 15 from bottom, *read*—

$$W_m = N_m \sin \alpha_m = V_m, \text{ instead of } W_m = \frac{h_m}{J x_m} = N_m \sin \alpha_m = V_m.$$

Page 60, line 8 from top, *read*—

$$W_m = \frac{M_m - M_{m-1}}{h_m} = S_m \cdot \frac{J x_m}{h_m}, \text{ instead of}$$

$$W_m = \frac{M_m - M_{m-1}}{h_m} = J S_m \cdot \frac{J x_m}{h_m}.$$

Page 236, line 8 from bottom, *read*—

$$\left(\frac{M}{h} \right)_3 = 0.01805 + (3.15568 - 0.0527) - 0.01, \text{ instead of}$$

$$\left(\frac{M}{h} \right)_3 = 0.01805 + (0.15568 - 0.0527) - 0.01$$

THE PROTECTION OF BUILDINGS AGAINST
WATER OVERFLOWS BY THE
MEANS OF ELECTRICITY.

BY LEOPOLD WEIL.

(Read at the Stated Meeting held Wednesday, May 16, 1888.)

JOS. M. WILSON, President, in the chair.

MR. WEIL: This subject was forcibly brought to my notice, some years ago, by having been subjected to two rather uncomfortable and expensive overflows of water, at my place of business.

We are protected against fire and theft, but there is no safeguard against water overflows, and the disquietude, caused by this fact, stimulated me in endeavoring to find means whereby I could protect myself, more especially as a loss of this nature would fall entirely upon me.

The damage caused by water overflows is a very serious matter, particularly in large cities, frequently causing a loss of many thousand dollars, and involving business houses in expensive litigation.

I have, therefore, devised a system which provides an efficient and reliable safeguard against damage to merchandise and other property from overflows of water in buildings, generally resulting from the bursting of pipes, stoppage of drains, or negligence, and sometimes from other causes.

The same consists of a method or system of automatically detecting an overflow, or leakage of water, in a building, which comprises means for directing such an overflow or leakage to an electric water-detecting device, which is normally inactive, but which becomes operative in the presence of water, to sound an alarm and shut off the water supply at the point of overflow or leakage, or to the building.

The water-detecting device, which I call a hydrostat, can be inserted in the floor, basin, tub or tank, according to the kind of protection required.

Horizontal pipes are incased in a wooden box, made to slant slightly, so that a leakage cannot escape, but will be led to the hydrostat.

In protecting a floor, the plumbing is confined within an area limited in extent by a line of one-half inch cleats nailed on the floor, from wall to wall, describing a circle or the shape required; within this enclosure a series of conveying grooves lead to a strainer inserted in the floor and on which is fastened a hydrostat.

The electric devices, by means of which, in case of an overflow, the hydrostat is made to shut off the water supply and sound an alarm, consist of a battery, alarm bell and a trip apparatus.

The first hydrostat I constructed consisted of two sets of conductors running at angles to each other and separated by a material which would act as an insulator when dry and become a conductor when wet. This was inserted in an aperture in the ceiling, directly under another aperture in the floor; the latter was supplied with a strainer and was situated at the base of a series of converging grooves, so as to catch any water which might overflow from the basin or other fixture. I found this apparatus entirely too sensitive, as a single drop of water was sufficient to shut off the entire water supply to the building, and furthermore the insulator became deliquescent from the moisture in the atmosphere, so I was compelled to abandon it.

I have different forms of hydrostats for various purposes; the one that I have here consists of a small vessel, provided with a suitable cap; there are openings to permit the ingress of water and exit of air; I place in the vessel a float, which rises when water enters, until it comes into contact with the conductor and forces its free end, which is connected with one binding post, against, and into contact with, the other binding post in the cap, thus closing the circuit and operating the system.

The trip apparatus consists of an electro-magnet; and an armature with a catch, which, in its normal position, engages with a lever. Upon this lever is suspended a weight, sufficiently heavy to operate the valve to which it is connected.

For the purpose of testing the system, I place in the circuit a test button; by pushing this button, the water ought to be turned off, and in order to denote this, I make a *break in the bell circuit*, which closes only after the valve has operated, thereby ringing this *bell*, which cannot ring unless the water has actually been shut off.

Now you have the system complete; you will imagine this hydrostat inserted in a basin or bath tub, as the case may be; I will first push the button to see if everything is all right. Now I will proceed to pour water into this vessel, and when it reaches the proper height, you will see, it operates the valve and precludes the possibility of an overflow by shutting off the water supply.

We can protect a basin, bath tub, tank, the pipes, the floor, or anything else as may be needed. A basin or bath tub provided with a hydrostat, can be made proof against sewer gas by dispensing entirely with the overflow holes. This is of great importance in many modern houses, where the plumbing adjoins the sleeping apartments.

When employed in hotels, the hydrostat is connected with the ordinary call bell circuit, and in this way the office will immediately be notified, and the room in which the leakage would have occurred be located and overflow prevented. In business houses the greatest danger exists at the time when the occupants have left the premises. This could be guarded against by shutting off the water when locking up, and it ought to be done every night, because unless there are people in the building there is certainly no use for any water. It is, however, frequently neglected through carelessness or forgetfulness, and *all* of the lawsuits which I have heard of in New York for damages from water overflows come under this category.

In order to provide an automatic method for turning off the water at night, I have provided a box into which must be placed the keys to the premises. I prefer to use the keys because they must be used in locking up at the time when no water is wanted in the building. The operation is, viz:

When the keys are removed from the lever, it closes the main circuit, and operates the valve.

The lever of the valve, when the water has been shut off, falls upon a spring which closes the alarm bell circuit; both circuits are now closed; the one having operated the valve to turn off the water and the other giving audible proof that this has been done. The bell continues to ring until the door to the box is closed. The valve cannot be kept open until the keys have been put back into the box, thus leaving the apparatus in condition to operate the valve to shut the supply pipe when the key is taken at night to close the building.

The apparatus can always be tested to ascertain if all the parts are in adjustment and good condition by opening the door of the box and removing the key. Thus in the morning when the box is opened to put the key in its place, the alarm will be sounded if the apparatus is in working order.

In closing, I merely wish to add, that a large insurance company is in operation in Frankfort, Germany, with a capital of 1,000,000 marks, and their business is to insure against damages caused by overflows of water in buildings; with the system I have described, no such precautionary measure is essential, but the very fact that in the old world, water damage insurance companies exist, demonstrates the necessity for some kind of protection in this respect, and I hope the time is not far distant when the term "Modern Improvements," as applied to buildings, will include a system for the prevention of water overflows.

REPORTS OF THE COMMITTEE ON SCIENCE AND THE
ARTS.

LANCE'S METHOD OF UTILIZING OIL-CLOTH WASTE.

[No. 1387.]

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, February 1, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination

WILLIAM L. LANCE'S METHOD OF UTILIZING OIL-CLOTH WASTE,

Report: That the object of the invention is to utilize the clippings or waste due to the trimming of sheets of oil-cloth. These trimmings are the unfinished margins of the cloth which are removed by the manufacturer prior to placing the finished material on the market.

Two results were placed before your Committee. One, the result obtained by removal of the applied substance necessary to form the cloth; the other, a carpet, the filling or weft of which was composed entirely of these trimmings.

The first process not being considered by the inventor to possess any real practical value was, therefore, not seriously considered by your Committee.

The second process was represented by a fabric (carpet) having a cotton warp with an oil-cloth filling. The latter is produced by cutting the oil-cloth waste into strips, joining the ends by means of a metallic loop, thus making a continuous strip, which is subsequently twisted so as to throw the painted side outward; these twisted threads, after having been wound into a cop for insertion into the shuttle, are introduced into the fabric in the ordinary manner of manufacture.

The fabric thus produced is very similar in appearance to the ordinary rag carpet, but as the material is not so pliable, the cloth is not so soft nor so compact as its familiar

counterpart. Whether it possesses the elements of desirability, sufficient to win its way as a commercial article, your Committee cannot determine. The process is certainly a novel one and the results obtained are so well defined that it would seem the fabric must eventually find its place in the ordinary household economy, its cheapness and durability being factors that count largely in its favor.

Its cleanliness is undeniable, as the nature of the material is to sift dust rather than retain it.

As before stated, your Committee are unable to properly judge of the practical results likely to follow this invention, but they are quite unanimous in their approval of the effort thus made by Mr. Lance to not only further diversify our manufacturing interests, but to give commercial value to that which has hitherto been valueless and everywhere recognized as a waste material.

All of which is respectfully submitted.

T. C. SEARCH,

WM. McDEVITT,

LOUIS H. SPELLIER,

H. W. SPANGLER.

Amended by the award of a Certificate of Merit.

Adopted April 4, 1888.

GEORGE A. KOENIG, *Chairman.*

THE DOUGHERTY RAILROAD SIGNAL.

[No. 1391.]

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, December 19, 1887.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination

THE DOUGHERTY RAILROAD SIGNAL SYSTEM,

Report: That the object and aim of the device is that a passing train shall automatically set signals and combinations for the guidance and control of trains following, in such a manner, that while the train setting the signal is notified

at the same time by a suitable alarm that the signal is properly displayed, it cannot alter the position of the same.

The signal being set, devices are provided connecting with the building occupied by a train operator, who alone can return the signal to its normal position. Should the office be vacant or operator off his guard, an alarm is given, and a corresponding signal displayed in the office, which will so remain until the operator has returned to his duty and has received notification that the train setting the signal has passed out of block. Thus following trains are brought to a halt until the signal is changed by the operator, allowing another train to pass.

The object is commendable and gives security from accidents. Any device that has the automatically-setting feature absolutely, and depending on an operator to change the signal back to normal position, is worthy of notice and theoretically seems perfect.

Your Committee do not deem it necessary to go through all the minute details of the signalling system presented, but take the initial or operating box that starts the machinery in motion as the real point of consideration. The device is constructed and operated as follows :

A box is provided, located alongside the rail and fastened to the ties with an opening in the top, through which a lug projects, that is secured to a semi-elliptic spring with elongated slots, the spring being secured to the bottom of box by bolts. The elongated slots allow the spring to expand freely. The lug projects upward and on the inner side of the rail, so that the flanges of wheels will strike and depress the spring, causing a downward movement, depressing a lever which is connected to the main lever, the latter being provided with a ball and tram-way. When the lever is in normal position, the ball or weight is located at or near the centre of motion. As soon as the lever is disengaged, the ball by gravity will roll along the tram-way out from the centre of motion, causing the lever to be depressed by the weight of the ball. The connections to operate the signals are at the opposite end of the lever. The lever with ball cannot be set, or returned, or set to normal position, without

the aid of the operator, connection being made with a building at any distance required for convenient signalling.

Your Committee are of the opinion that the device is mechanically practicable and effective and fully able to accomplish the object desired, and, although not seeing the device in practical use, believe the principle to be good, and worthy of commendation.

Therefore, your Committee would suggest that the device be tried practically on some road to develop the mechanical working of the same.

For further information as to details, the patent papers and illustrated pamphlet of the inventor are appended hereto.

RUFUS HILL,

W. BARNET LEVAN,

LUTHER L. CHENEY,

C. CHABOT,

CHAS. E. RONALDSON.

Adopted April 25, 1888.

GEORGE A. KOENIG, *Chairman.*

SCIENTIFIC NOTES AND COMMENTS.

MECHANICS.

A VIBRATING ENGINE.—There is being built in Portland, Me., an engine which is the invention of Mr. Lidback, which has quite a number of novel features. I have called it a vibrating engine to distinguish it from a rotary, as the driving apparatus turns through part of a circle. The piston consists of a hollow cylinder, having four wings on its outer side. The outer edge of these wings carry packing pieces, which bear against the inner surface of the steam cylinder proper. Between the wings rectangular plates extend inwardly from the steam cylinder, which are made to bear against the outside of the cylindrical part of the piston. Each wing of the piston is therefore between two of these plates, and moves backward and forward as the piston vibrates. *Fig. 1* will give a fair idea of the arrangement of the parts. *AA* is the piston carrying the wings *BBBB*, each of which is packed by the rectangular piece *C*, against the interior of the cylinder *D*. *EEEE* are the plates fitting into recesses in the cylinder *D*, and set up by set screws, two of which are shown at *FF*. *H* is the valve chamber, and steam is admitted through the centre of the piston. Ports are cut through the piston *A*, at *GG*. Two ports, one for steam and one for exhaust, are in each corner, but one lies at one end and one at the other of the piston *A*. The valve used is represented in *Fig. 2*. It consists of a cone-shaped piece of cast iron, *H*, having steam

ports, *I*, and exhaust ports, *K*, cut in it. Steam is admitted through the pipe *L*, and passes through *I*, into the opening in the piston and into the cylinder. The exhaust is taken through the port *K*, into the exhaust pipe. With larger

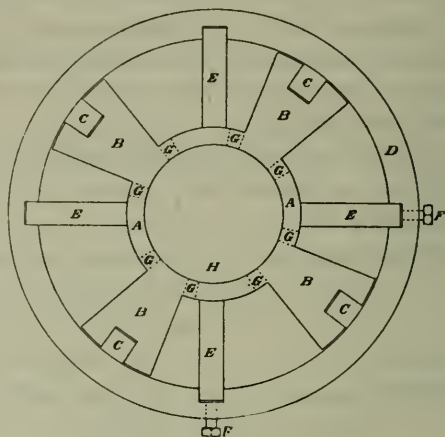


FIG. 1.

sizes separate valves are used, and do away with heating the exhaust from the live steam. The spindle supporting the piston passes through a long

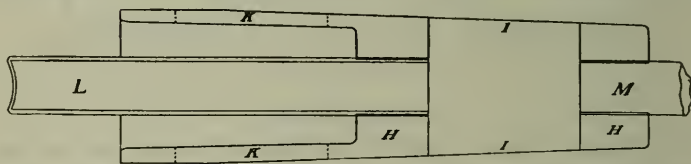


FIG. 2.

bearing, and carries on its end an arm to which the connecting rod is attached. The fly-wheel shaft is carried in the same casting, and is directly over the

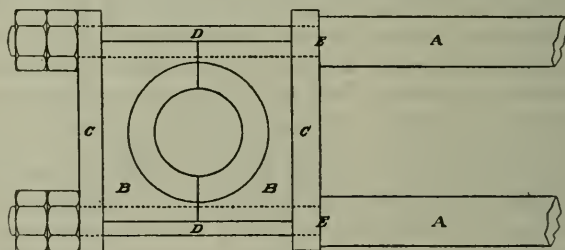


FIG. 3.

cylinder. It is driven directly by the connecting rod, and carries on it what is practically an eccentric for moving the valve. On the smaller sizes a throttling governor is used, but on larger sizes a shaft governor is fitted, which

varies the point of cut-off. A ten horse-power engine, single cylinder, weighs about 600 pounds complete, while a ten horse-power compound weighs a little over 300 pounds. They can be run satisfactorily up to 1,000 revolutions, but generally are speeded at about 250. As the most important thing about an engine of this kind is the method of making the piston steam tight, it is here more fully described. The rectangular pieces, *C*, *Fig. 1*, fit snugly into the recesses prepared for them, and, as the steam is admitted on one side or the other, they are thrown against the opposite side and out against the cylinder by the steam pressure. The plates, *E*, are carefully finished along the inner edge and are set up from the outside. Steam is prevented from passing over the ends of the vanes or wings. At one end the piston head is fitted against the end of the cylinder and piston by scraping, and the plates, *E*, are recessed into the head. The other end of the cylinder is made of a plate, which is recessed for the ends of the plates, allowing a movement of the plate axially, and the piston and the plate present scraped surfaces to each other. This plate is set up by set screws on the outside. The tightness depends, therefore, on the accuracy of the surfaces originally and the care with which it is set up. Engines have been built varying from one and one-half to 100 horse-power, and have proved to be as tight as desired. The small floor space and head room required is not the least of the advantages of these engines. The connecting rods are quite ingenious and to me new. The brasses for each end are cast and fitted as shown in *Fig. 3*. The two ends are alike. *BB* are the brasses; *CC* are two rectangular plates fitting over the rods *AA*, which are smaller at *D* than at *A*, having a shoulder at *E*. The brasses and plates are held on by the nuts, as shown. The brasses are prevented from moving, as the rods *D* are recessed into the sides of the brasses.

H. W. S.

ENGINEERING.

THE pontoon bridge over the Missouri River, at Nebraska City, is said to be the largest in the world. Its length across the navigable channel is 1,074 feet, while the back channel is traversed by a causeway 1,050 feet long, supported on cribs. The charter for this bridge has been held for twelve years, because of the difficulty of obtaining financial support for a project which appeared so impracticable. It is stated that the entire bridge was built in twenty-eight days, at a cost not exceeding \$18,000, by Col. S. N. Stewart, of Philadelphia, assisted by General Lyman Banks, of Iowa.

The draw is V-shaped, with the apex down stream. It is operated by the current and controlled by one man. The clear span is 528 feet, the largest in the world. The bridge was completed in August and is doing good service. It will be removed during the ice season. H.

REMOVAL OF SMITH'S AND WINDMILL ISLANDS, PORT OF PHILADELPHIA.—The Committee on Commerce, of the United States Senate, have recommended the appropriation of \$550,000 for the beginning of this work, of which \$350,000 is to be available for the purchase of the lands, leaving \$200,000 for procuring plant or for prosecution of work. The total estimate to complete,

as made by the Board of United States Engineers, is \$3,500,000. At this rate it will require seventeen and one-half years, provided there be no failure of the bills during that period, and that the item be not scaled down. As yet there is no law nor provision requiring the riparian owners to extend their wharves to the proposed new line as the work progresses, and unless this is done, the work will prove a failure. H.

THE steel bridge on the Northern Pacific Railroad at the Missouri River crossing, between Bismarck and Mandan, is said to be in danger from a threatened landslide from the bluff on the left bank.

THE NICARAGUA CANAL.—Mr. A. G. Menocal, Engineer-in-Chief of the Nicaragua Canal Company, who is at present in New York, expressed himself in the following terms respecting the present status and prospects of this enterprise.

With the exception of some local work, the canal surveys are now about finished, and the perfected route as it now stands is at least twenty-five per cent. better than the one of 1885. The then estimated length of forty and three-tenths miles has been cut down to twenty-eight and eight-tenths miles, and the small surveys now going on are expected to reduce this to nearer twenty-eight miles. Everything is now waiting in readiness for the work of construction to begin, and on this trip Mr. Menocal is to interview the officers of the company to that end.

The people of Nicaragua and Costa Rica are awaiting the opening of the canal with the greatest interest, and confidently expect a wonderful development of the resources of their country when it becomes a settled fact. Mr. Menocal says that all the members of his staff have worked like beavers during the last season, with the exception of the physicians. They had absolutely nothing in their line to do, and to keep themselves from rusting from sheer inactivity, held chains for the surveyors, took barometrical observations and the like. The whole party slept in the open air every night, with no other protection than a canvas tent, and sometimes not even that; yet all were benefited rather than injured by the experience.

Mr. Menocal now has three divisions of engineers, eighteen in all, and a full complement of native laborers busily at work finishing up every detail of the surveys, and expects to have every inch of the route mapped out by the time he returns. There are no particular engineering difficulties to be surmounted in building the canal.

The heaviest part of the work is the making of a cut 119 feet deep through a two and three-quarter mile stretch of solid rock. About sixteen miles of the work will be dredged and the balance of nine miles is firm, low-lying ground that will only have to be dug to a depth of twenty feet. The canal is to be 120 feet wide, through the greater part of the distance, with sharply sloping sides that will not have to be walled up. Through the rock section it will be but eighty feet wide with nearly vertical sides. The whole canal will have an average depth of thirty feet, and will be able to accommodate the deepest draught vessels.

Once the work of construction is begun it can be carried on very rapidly, and the project will become a certainty in a very few years. The almost constant surveys since 1872 have made the engineers thoroughly familiar with every part of the ground and the chances of delays caused by unforeseen difficulties are reduced to a minimum. Mr. Menocal expects to see President Cheney and his colleagues very shortly, and get his orders to return and actively begin the working out of one of the greatest projects of the age.

W.

THE PANAMA CANAL.—The *Engineering News* has lately published an article on the actual status of the Panama Canal, giving the results of a recent expert examination of the entire length of the canal, and accompanied by a progress profile, showing the amount of work done and undone to January 1st of the present year, both for the sea level and lock canal. The profile shows that the only work which is anywhere near completion, is about eleven miles of dredging on the Atlantic end and about a mile at the Pacific end. On the remainder of the work the proportion done is very small in comparison with that undone. The estimate given in connection with this profile shows a total of 34,081,000 cubic metres remaining, without allowing for the changes of river channels, Gamboa dam, etc., which raises the aggregate to 51,000,000 cubic metres. The company had admitted 32,000,000 to 40,000,000 metres.

At the highest rate yet reached of 1,000,000 cubic metres per month, it is estimated that at least four years will be necessary to finish the canal, if there is no lack of money.

The total amount of cash actually expended up to the present date is \$177,910,000, represented by \$351,150,900 of securities.

The amount necessary to be raised to complete the canal is estimated by the *Engineering News* at a minimum of \$230,000,000, which would be represented by at least \$500,000,000 of new securities.

The article declares that the progress profile makes it evident that not one-tenth of the work, nor one-twentieth of the money has yet been spent, which would be required to open a sea-level canal, which Lesseps declared last November would be opened February 3, 1890. Therefore, we can only escape from the conclusion that the impossibility of completing a sea-level canal has been known for three or four years at least by assuming colossal ignorance, either of which is equally fatal to their creditability in regard to the lock project. The worst feature of the progress profile to those familiar with the proper conduct of public works, is not so much the small aggregate of work done, but the distribution of it, in the damning evidence it bears that all has been done for theatrical effect, to facilitate "raising the wind" by producing an impression in the ignorant and unthinking, rather than to so conduct the work as to complete it in the least time at the least cost. The worst feature of all is the completed section on the marshes, which should not have been touched at all until the heavy work was nearly done. The next worst, is doing so much work where it is likely to be washed out by floods in the Chagres River, without completing the costly and doubtful damming and diversions of that river which are hardly yet begun.

W.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

- American Academy of Arts and Sciences. Proceedings. Vol. 15.
From the Society.
- American Institute of Mining Engineers. Transactions. Vol. 16.
From the Institute.
- Babcock Printing Press Manufacturing Company. Illustrated Catalogue.
From the Company.
- Bureau of Navigation. Navy Department, U. S. General information
series No. 7. Information from abroad. June, 1888.
From the Department.
- Chronicle Fire Tables, 1887. From the Chronicle Company.
- Commissioners of Sewerage and Water Supply for the city of Saint John.
Annual Statements, 1887. From the Commissioners.
- Connecticut Academy of Arts and Sciences. Vol. 7. Part 2.
From the Academy.
- Elisha Mitchell Scientific Society. Journal. 5th year. Part 1.
From the Society.
- Fowler, J. A. History of insurance in Philadelphia for two centuries. Phila-
delphia, 1888. From the Author.
- Hart, W. F. Information on the patent law of Great Britain, etc.
From the Author.
- Hydrographic Office, U. S. Pilot chart of the North Atlantic Ocean. Sep-
tember, 1888. From the Office.
- Illinois State Laboratory of Natural History. Bulletin, 1888.
From the Laboratory.
- Keep, W. J., and Thomas Turner. Notes on American foundry iron.
From Mr. W. J. Keep.
- Krupp and DeBange. By E. Monthaye. From Thomas Prosser & Son.
- Louisville and Nashville Railroad Mineral Resources of the Upper Cumber-
land Valley. 1888. From the Railroad Company.
- Manchester Steam Users' Association. Report of the Proceedings. 1888.
From the Association.
- Massachusetts State Library. Report of the Librarian for 1887.
From the Library.
- Meteorological Council. London. Atlantic Weather Charts. Part 4.
From the Council.
- Meteorological Observations recorded at six stations in India. January to
April, 1888. From the Government.
- Michigan Board of Health. Proceedings at a Sanitary Convention held at
Albion. 1887. From the Board.

Miller, Metcalf and Parkin. Condensed suggestions for steel workers. New York. From the Publishers.

New Jersey Historical Society Proceedings. No. 1. Vol. 10. Second series. From the Society.

New York Academy of Sciences. Annals, Nos. 5, 6 and 7. Vol. 4. Transactions, Nos. 3 to 6. Vol. 7. From the Academy.

Ohio Agricultural Experiment Station. Bulletin No. 5. August, 1888. From the Station.

Patent Office, U. S. Annual report of the Commissioners of Patents for 1887. From the Office.

Specifications and Drawings. February 1887. From the Office.

Pennsylvania. Adjutant-General's Report. 1887.

Agriculture of. 1887.

Auditor-General's Report. 1887.

Banks and Savings Institutions Reports. 1887.

Common School Laws. 1888.

Fire and Marine Insurance Report. 1887.

Internal Affairs. Part 1. 1887.

Official Documents. Vol. 1-5 and maps. 1887.

Public Instruction Report. 1887.

Soldiers' Orphans Report. 1887.

State Librarian's Report. 1887.

State Treasurer's Report. 1887.

Superintendent of Public Printing Report. 1887.

From the Librarian of the Senate.

Vetoed by the Governor of Bills Passed by the Legislature. Session of 1885 and 1887.

From the Secretary of the Commonwealth.

Royal Irish Academy. Proceedings, Science. Series 2. Vol. 4. No. 6.

Polite Literature. Series 2. Vol. 2. No. 8.

Transactions, Science. Vol. 29. Parts 1 and 2.

List of Papers Published in the Transactions, etc. 1887.

Cunningham Memoirs. No. 4.

From the Academy.

Sang, E. On cases of Instability in Open Structures. February, 1887.

From the Author.

Signal Office, U. S. A. Daily International Chart. June and July, 1887.

Summary and Review of International Meteorological Observations. June and July, 1887.

Smithsonian Miscellaneous Collections. Vols. 32 and 33.

From the Smithsonian Institution.

Springfield, O. Eighth Annual Report of the Water Works for 1887-88.

From the Secretary of the Works.

University of California. Addresses at the Inauguration of Horace Davis as President.

University of California. Register of the University. 1887-88.

From the University.

U. S. Department of Agriculture. Annual Report of the Forestry Division for 1887.

Division of Chemistry. Bulletin No. 18.

Division of Pomology. Bulletin No. 2.

Report of the Statistician. No. 54.

From the Department.

Wisconsin State Historical Society. Report and Collections. Vol. 10.

From the Society.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, September 19, 1888.*]

HALL OF THE INSTITUTE, PHILADELPHIA, September 19, 1888.

Mr. JOS. M. WILSON, President, in the Chair.

Present, 249 members and thirty-nine visitors.

Additions to membership since previous report, seven.

The Secretary reported the declination of Mr. THEO. C. SEARCH, who had been elected to the Board of Managers to fill the unexpired term of WILLIAM HELME, deceased. Mr. JOHN LUCAS was elected to fill the vacancy.

Mr. HENRY PEMBERTON, JR., read a paper entitled "An Inquiry into the Relative Value of Aluminium and its Alloys in the Arts." The paper appears elsewhere in this impression of the JOURNAL. Mr. W. E. GUMP, of New York, read a paper descriptive of the system of the Writing Telegraph Company, embracing the Cowper-Robertson system of autographic or *fac-simile* telegraphy. The subject was illustrated by the exhibition of the system in actual operation. The paper appears elsewhere in this issue of the JOURNAL.

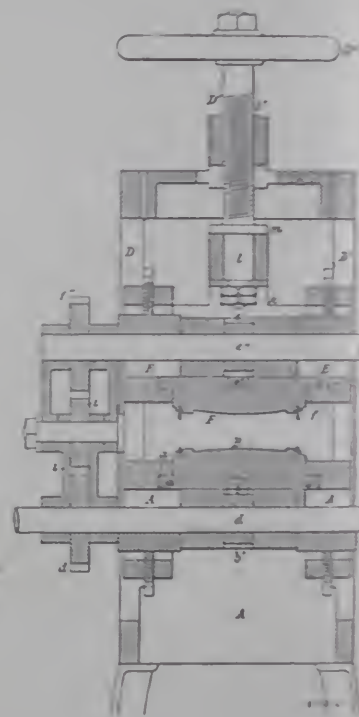
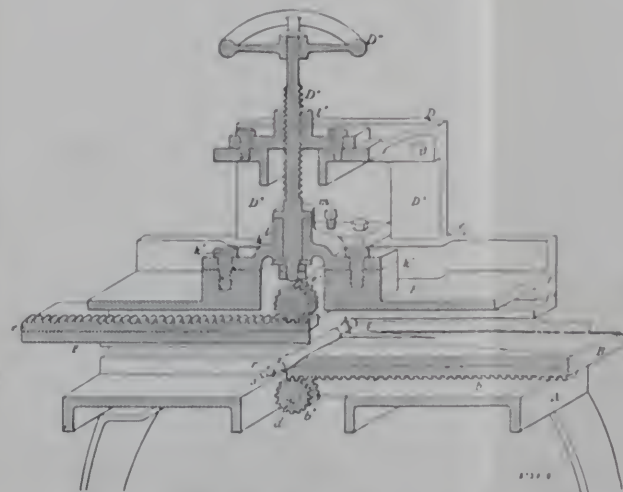
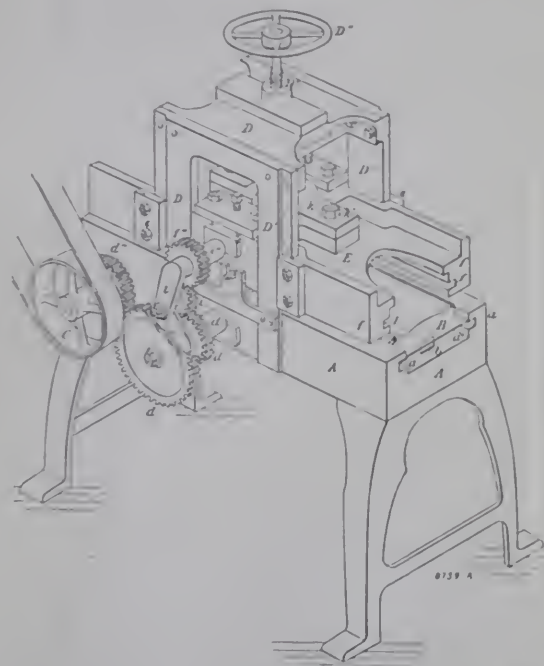
Prof. ELIHU THOMSON, of Lynn, Mass., gave an oral account of the system of electric welding which he had invented, with especial reference to the machines and appliances that had been devised for carrying the process into operation. He illustrated his remarks by a practical demonstration of the operation of electric welding. An abstract of Prof. THOMSON'S remarks has been prepared for publication.

The subject of the Cowper-Robertson writing telegraph was referred to the Committee on Science and the Arts for investigation.

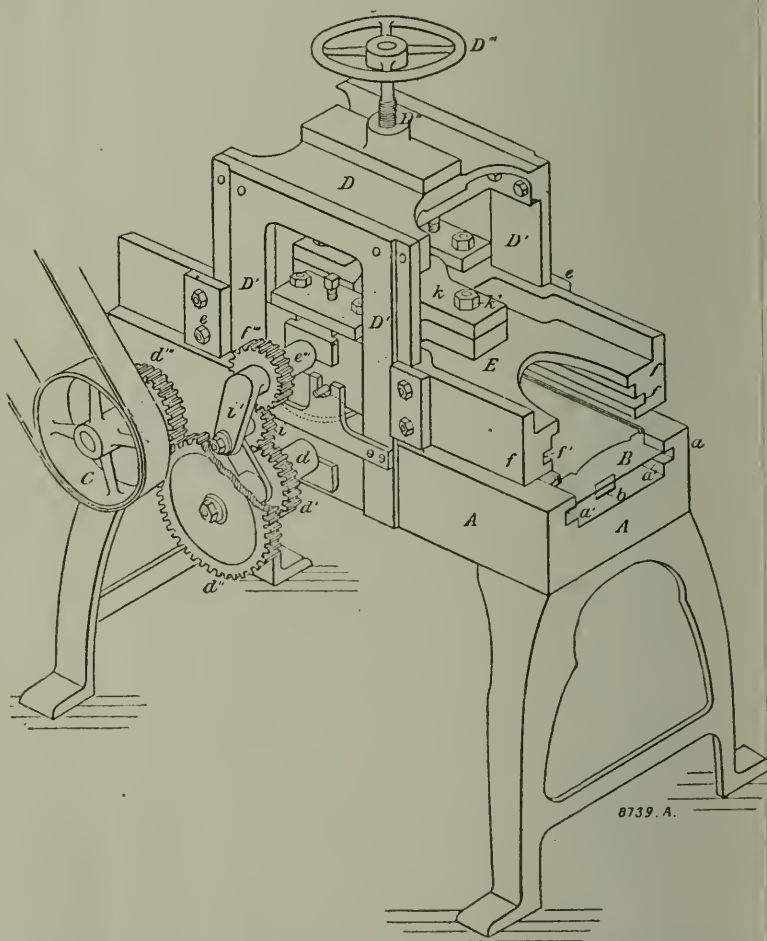
A communication by Mr. W. E. LOCKWOOD, on the subject of the Hammer-Blow of Locomotive Driving Wheels, was referred to the same committee, with power to act.

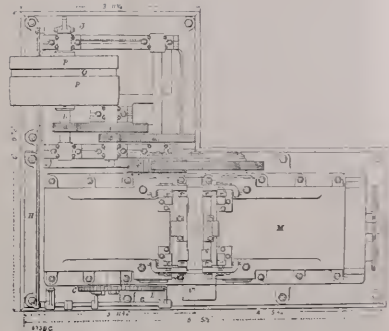
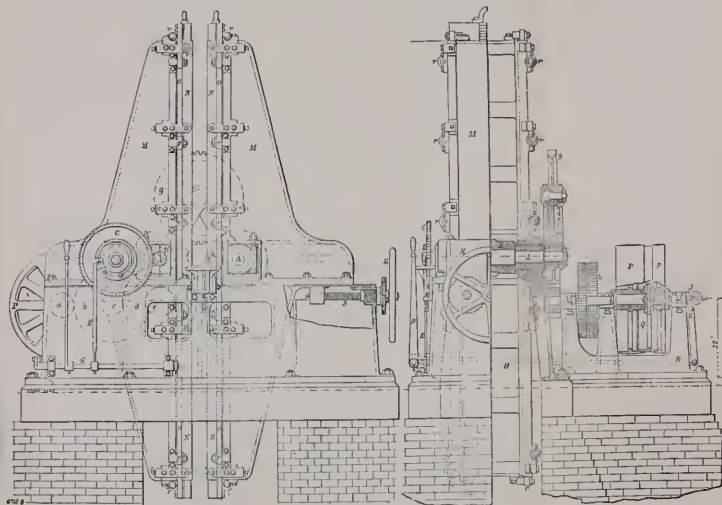
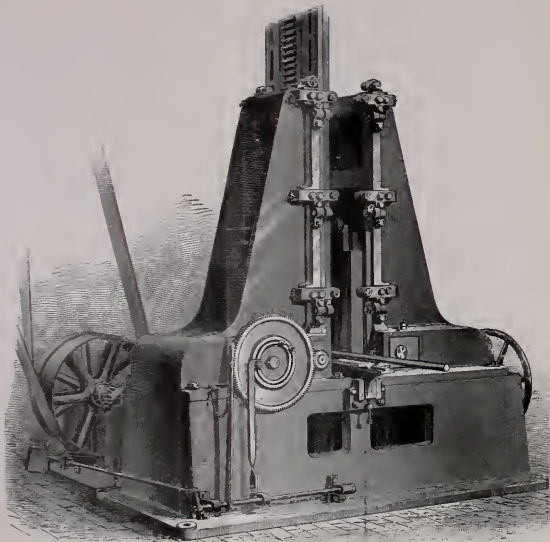
Adjourned.

WM. H. WAHL, *Secretary*.

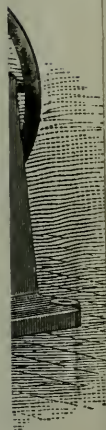


SIMONDS'S UNIVERSAL METAL ROLLING MACHINE (Simonds' U. S. Patent No. 319,752).





SIMONDS'S UNIVERSAL METAL ROLLING MACHINE (Perspective View, Vertical Sections and Plan).





Specimens of Products of Simonds's Rolling Machine.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,
FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI. NOVEMBER, 1888. No. 5.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS.

ON THE SIMONDS UNIVERSAL METAL-ROLLING MACHINE.

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, September 5, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination

GEORGE F. SIMONDS'S ROLLING MACHINE,

Report: That they have carefully examined the same and considered his request for the award of the Elliott Cresson Medal of the FRANKLIN INSTITUTE, and find as follows:

The invention, in its general scope, is included in the letters-patent of the United States, numbered 319,755, and dated June 9, 1885, granted to George F. Simonds, of Fitchburg, Mass., for "Method of Forging Metal Bars," submitted

to your committee by the inventor, with his application. There are thirteen other letters-patent granted to the same inventor for the machines and instruments for performing this and collateral work, and for the products of such machines numbered, dated and entitled, as follows :

Four, dated June 9, 1885, viz :

No. 319,752. Machines for forging car axles and other metal articles.

No. 319,753 for machine for making car wheels.

No. 319,754 for dies for forging metal articles circular in cross-section.

No. 319,756 for die for spherical articles.

Three, dated September 7, 1886, viz :

No. 348,788 for shell and method of making the same.

No. 348,789 for armor piercing shell.

No. 348,790 for dies for making rolled forgings.

Three, dated November 9, 1886, viz :

No. 352,365 for die for making rolled forgings.

No. 352,366 for roller swaging die.

No. 352,367 for making metal rolling dies.

Three, dated March 1, 1887, viz :

No. 358,627 for rolled conical projectiles.

No. 358,628 for die for making rolled forgings.

No. 358,629 for die for making rolled forgings.

The object of the invention is the economical and accurate production from ductile or malleable metal articles of circular, or approximately circular form, other than simple cylinders.

The means resorted to for attaining such results concisely stated, consist in swaging dies moving in opposite directions with surfaces which approach each other and first roll the ductile metal to form and afterward produce, by continued rolling, a finished surface.

The important feature distinguishing this invention from other devices having a like object in view, is the extension or drawing of the metal of a rod in the direction of its axis, attended with a reduction of diameter in whole or in part, in contradistinction from attempting to shorten or upset the metal, and thicken portions of the metal to a greater diam-

eter than that of the rod, and with this further feature the avoidance of any attempt to finish the surface until the metal has been shaped in the form required for the completed article.

The machine exhibited to your committee, in operation at the works of William Sellers & Co., incorporated, No. 1600 Hamilton Street, in this city, consists of two vertically reciprocating sliding tables, moving in guides simultaneously at equal velocities in opposite directions by racks and pinions, propelled by a train of toothed gearing operated by pulleys turning in reverse directions, and alternately engaged therewith by a coupling or clutch, the coupling being operated by a shifter, participating in the motion of the gearing propelling one of the slides; one of the guides with its sliding table is adjustable, as to distance from the other, so as to make required changes in the diameter of the work produced.

The dies are fixed to the inner sides of the slides and are of such form, that as one descends and the other ascends, the space between them diminishes.

A heated bar of metal being placed between them, is rolled thereby whilst its axis retains the same position.

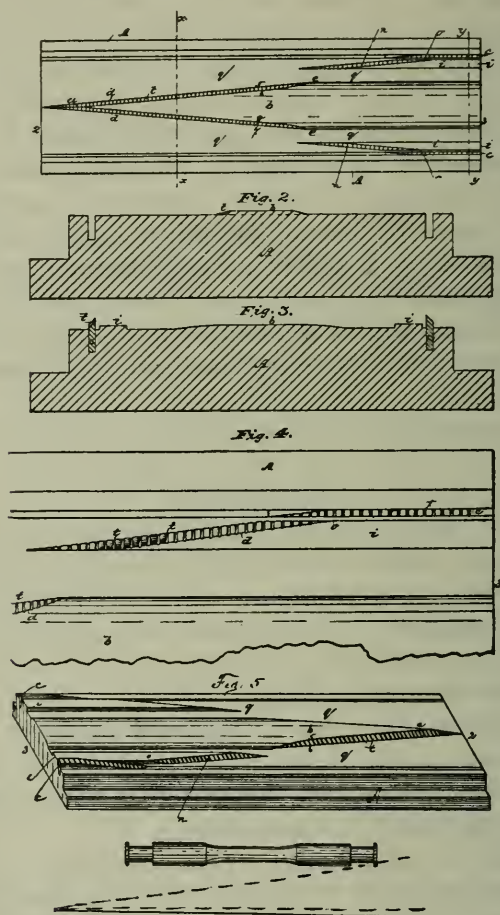
The working faces of the dies are inclined as to the direction of their motion, so as to draw the metal lengthwise, in the direction of the axis of the bar, on material of requisite strength and homogeneousness.

The rotation of the bar is enforced by teeth formed in the prominent parts of the dies, indenting the metal and thus turning it, like two oppositely-moving racks would turn a pinion placed between them.

In no part of the operation is the compression or shortening of the metallic bar in the direction of its axis attempted.

The reduction in diameter is gradual, so that, in material of a reasonable degree of strength and homogeneousness, there is never a severance of metal at the centre by the metal being flattened and moving in opposite directions at the centre, producing what is known as piping or a hollow centre; but instead an extension in the direction of the axis. This effect is produced by the gradual inclination of the

dies toward each other, attended with a relatively very rapid divergence of the prominences or ridges and intervening cavities of the dies. This configuration of the dies proceeds to the point where all parts of the article are



Simonds's U. S. Patent No. 319,754.

reduced to the proper diameter. In the rest of its length the ridges or working surfaces of the dies are parallel and finish or smooth the surface of the article.

A good illustration of the shape of the dies appears in Figs. 1, 2, 3 and 5 of Simonds's patent, No. 319,754, showing

the dies, and below a car axle produced by their operation, which figures are here inserted and now explained in detail.

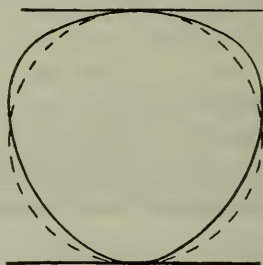
The foremost portion of the dies are marked *z*, being at the left end of *Fig. 1*, and the right of *Fig. 6*. The portions of the dies marked *q q* are sufficiently low or thin to permit the heated rod to pass freely between them, the weight of the rod being supported by a rest outside of the path of the dies. An inclined part rises from the point marked *z* to the point marked *a*, and gradually widens from the point *z* to the points *e*, being parallel or nearly so with its line of motion from the point *a* onward; the edges of the triangular part *a, e, e*, being bevelled and having teeth formed in them which indent the metal and ensure rotation of the bar. It will be seen thus that the dies engage the bar at the centre, leaving the ends free, and gradually reduce its diameter from the centre toward the ends. This action continues until the reduction of diameter of the central parts of the axle is effected, after which this part simply rolls between the parallel parts, extending from the points *e e* to the end of the die marked *3*.

Upon the completion of the reduction of diameter of the central parts, two raised portions of the die, marked *i i*, parallel on the inner edges with the line of motion and gradually rising from the plane surface *q q*, and widening to the points marked *o o* with bevelled and toothed outer edges, marked *n n*, engage and roll the bar, stretching it in length; after reaching the points *o o*, the raised portions *i i* extend with parallel and smooth perpendicular edges to the end *3* of the die. It will be observed that the parts *i i* throughout their tapering portions by their toothed and bevelled edges roll the metal between them, and force it outwardly, leaving the form of the parts between the bevelled edges unchanged, thus forming the reductions in diameter required for the journals of the axles. After the parts marked *o o* of the die reach the bar, the extension of metal ceases, and a smooth rolling of surfaces proceeds. At the same time that the parts *o o* of the dies pass the rod, which by this time has become an axle, two raised portions of the die marked *e e*, rising gradually above the surface *q q* to the height of the centre

of the axle, and having smooth perpendicular inner sides, and bevelled and toothed outer sides, engage the metal and roll circumferential grooves in it, which increase gradually in depth, until the superfluous metal is severed from the ends of the then completed axle.

In order to afford a clearer conception of the direction of inclination of the working surfaces of the dies to their line of motion, and thus indicate the relative slowness of the diametral reduction to the lengthwise extension of the forging, three lines are drawn beneath the figure of the axle. The horizontal full line indicates the line of motion of one of the dies; the dotted oblique line nearest to it, the rate of diametral reduction, and the upper dotted line the rate of lengthening or drawing out of the forging.

It is found experimentally that a rod having a form of a triangle, with convex curved sides and corners, containing a greater mass of material than a cylinder of the same diameter, will roll between two parallel surfaces moving in opposite directions. If these surfaces in the dies of this machine are so shaped as to approach each other more rapidly than the metal is disposed of by drawing out lengthwise, such a form of section results and the metal in the

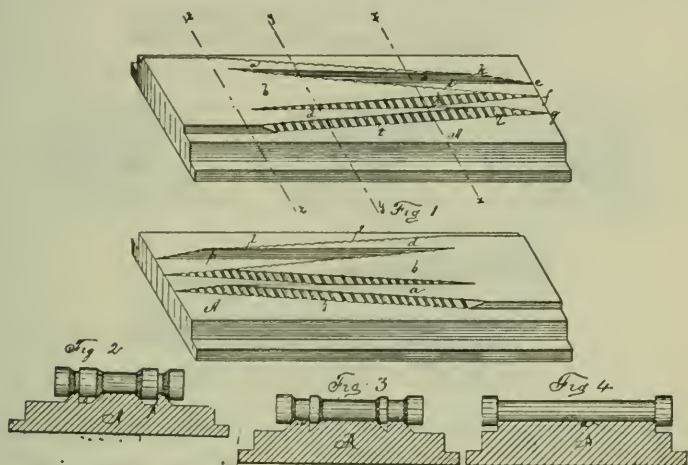


centre of such form is not solid but hollow or piped. This is illustrated in the figure showing the relative size and forms of the circle and curvilinear triangle, the proportions of which are exaggerated, to more fully show the feature involved.

As above described and shown, the extension in length and reduction in diameter commenced at one point in the centre of length and extended toward the ends, but the

invention is not limited to this mode, as shown in the next drawing taken from Simonds's U. S. Patent, No. 319,755.

The extension commences at three points in the length of the bar by three working faces marked *a*, *c* and *d*, on the dies commencing at points marked *e*, *f* and *g*, the inside



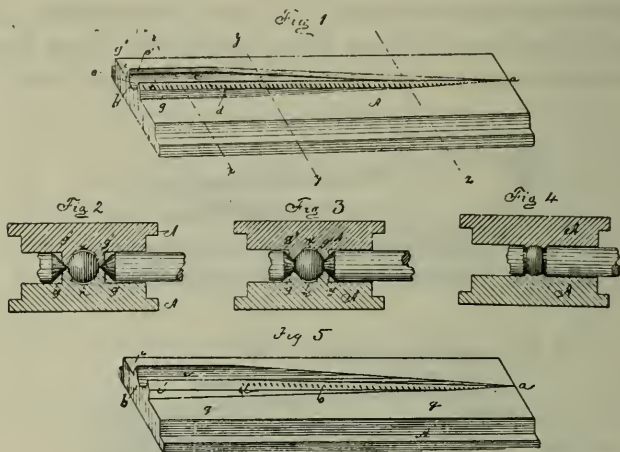
Simonds's U. S. Patent No. 319,755.

lines of the outer working faces *a* and *d* diverging from the points *e* and *g*, so as not to impede the extension of metal by the central working face *b*. As compared with the dies first described, the operation of these outer additional working faces is simply cumulative, and the advantage derived from them is that the work is accomplished more quickly by shorter dies in a machine of less stroke than would otherwise be required.

The other patents relate to the application of this system to the production of special forms, such as solid spheres and hollow shells for projectiles, and to details. A patent for rolling car wheels is also submitted, but is not in the opinion of your committee properly within the scope of their inquiry.

That for spheres, Simonds's U. S. Patent, No. 319,756, has transverse cavities, extending partially across the working faces of the die, passing over parts of the forging already shaped, which avoid part of the friction incident to dies, when the working faces are continuous, and corre-

spondingly avoid torsional strain upon parts of the forging which, if otherwise, would result from enforced contact of



Simonds's U. S. Patent, No. 319,756.

parts of different circumference and velocities, with the surface of the dies moving in all parts at the same speed.

The earliest form of the Simonds rolling forging machine is here shown, taken from Simonds's U. S. Patent, No. 319,752. (*See inset plate.*)

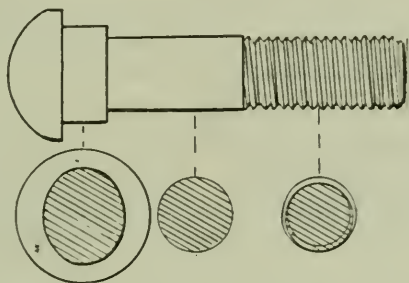
Whilst it differs in form from that now in use, it embodies the method or system of operation above explained, and upon which the value of the invention rests. The slides, with the dies moving simultaneously in opposite directions, are present with the inclination of surfaces of the dies, and the divergence and bevelling of the drawing surfaces and, with a machine so constructed, the feasibility of the invention was tested and demonstrated.

So far as described, the invention appears only as applied to the production of smooth-surfaced articles of circular cross-section.

As demonstrated by the machine in operation, above referred to, the invention is also successfully applied to the making of articles having prismatic and other forms of cross-sections in parts, and also with screw threads, such as bolts for railway splice joints.

These bolts have, as shown in the drawing here inserted, hemispherical heads, an elliptic or flattened part next to the head, a cylindric shaft terminating in a screw-threaded portion having a blunt conical point. The forms of cross-sections are represented below at the several points in the length.

The bolts thus made are produced at the rate of five per minute, and with such accuracy that a standard nut fitting the first hundred bolts made, fits equally well on the last hundred bolts, in lots of from 5,000 to 10,000 without renewing, changing or in any manner adjusting the dies; the portions



of the forgings, which depart from a circular form of cross-section, are made by correspondingly wave-shaped elevations and depressions in the working faces of the dies, the rotation of the bar being enforced by teeth in the working faces engaging either the surfaces of the forging or of a part of the bar contiguous thereto.

A card of specimens of the work produced demonstrates the extensive applicability of the invention, and consequent almost incalculable value for work of which many duplicates are required. (*See frontispiece.*)

The work, as it leaves the machine, approaches lathe-turned work in accuracy of form and dimensions. The effect of this method of treatment of metal is to improve its qualities of tenacity. The manner in which the metal is displaced from the parallel or cylindric forms, in which it enters the machine, to the tapering or shouldered forms which it assumes in the finished product, is shown by sections of the articles which have been polished and etched with acid, showing by the streaks and veins the direction of the flow

of metal under pressure. The lines of the veins show that the fibres are unbroken and in no case bent back upon each other.

For purposes of comparison an iron bolt of the same pattern has been similarly treated and placed with the others, the direction of fibres in upset iron specimen plainly appearing.

The Simonds specimens are uniformly solid in all parts.

It is evident that the superior strength and uniform density in all parts as compared with castings either of steel or iron, considered in conjunction with the celerity and low cost of production, in competition with the expense of moulding and melting and casting metal, must cause the roll forged projectiles made by this method to supersede all others yet known.

The extent of changes and better developments in this and of dependent collateral manufactures, to be reasonably expected as a result of this invention, appears to your committee as so great as to be practically incalculable. Tests of the tenacity and ductility of the bars of material made by the Fairbanks testing machine, at Seventh and Arch Streets, in this city, show that the bolts produced by the machine retain the ductility and strength of the bar before it is subjected to the operation of the machine, as will appear in the following report of tests made in the presence of and observed and recorded by your sub-committee, on the 18th day of August, 1888.

Eleven specimens were tested, and the results recorded for the purpose of comparison are here tabulated, together with sketches describing the several specimens with these tests of the products of the Simonds machine. There were also made, for purposes of comparison, tests of similar standard bolts, made by Messrs. Hoopes & Townsend, of this city, and recognized by all of the principal railway companies as the best in use. The tests are numbered 1 to 11, and show the bolts produced by this process to be of superior quality and strength, as will appear upon inspection of the tabulated report of the test, shown upon the opposite page.

The parts of the specimens tested are fastened to a card, and numbered to correspond with the order in which the tests were made. Our examination of the fractured parts shows that the tenacity of the material is unimpaired by the Simonds method of working.

A comparison of the tests of bolts made with those of the best manufacture heretofore known, strongly commends those of the Simonds manufacture. It is noticeable that the iron nuts used in making the tests appear to be equal in



Specimens of Bolts Tested by Committee.

strength to the steel bolts, the strongest steel bolt tearing the thread out in the first test, and in the second, fourth, fifth, sixth and seventh breaking the bolts.

There can be no doubt but that a reduction in diameter occurs at the instant, or in the act of severance, and the resulting area being thus diminished, the computation shows a greater tensile strength per square inch of $\times$ -section than actually existed, which fact should be kept in view in considering the resulting figures.

The specimen (No. 10) of bar iron, from which the Simonds iron bolt was made, being quite short, slipped from the clamps of the testing machine after the extension in length had commenced, and an increase of strength resulting from the intermission of strain appears.

An important feature of value in the application of this invention to the production of screw bolts, is that the shafts of such bolts can readily be made between the screw threads and the bolt head, equal in diameter to the base of the screw threads. This is important not merely as a saving of material, but is of great value in increasing the range of both elastic and ductile extensibility of the bolts, which as bolts are usually made, is limited to the breadth of the lines of the base of the threads, at which points they often break under concussive or other sudden strains; whilst in bolts having their shafts equal diametrically to the base of the threads, the elastic and ductile properties of such a length become operative as to receive and distribute the strain without injury.

The invention appears to your committee as especially valuable in its application to the making of stay bolts of boilers, the surface of the bolts being throughout, both thread and shaft, compacted and effectually covered and protected by a skin of magnetic oxide, resisting corrosion; and, in addition to this, the facility of rolling threads close to a shoulder, permits of the production commercially of stay bolts heretofore desired, but too expensive to use. A strict compliance with the regulations of the navigation laws for boiler inspection is thereby facilitated, and for this it should be highly commended.

As compared with iron, manipulated in the usual way, the sections of machine-rolled iron articles produced by the Simonds method, exhibit, when tested with acids, a skin or layer of surface metal very slow to corrode, and in steel specimens the resistance to corrosion is still more marked.

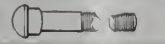
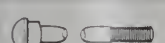
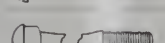
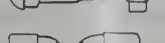
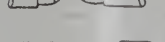
The value and prominent importance of this invention, in furnishing accurately-made forgings in large numbers of better quality than were ever before procurable, and at greatly reduced cost, impresses your committee so strongly

*Four, Four**(Committee.)*

FORGING MACHINE.

No.	MATERIAL.	Pounds Strength per Sq. Inch. Original X Section	Pounds per Sq. Inch. Final X Section.	REMARKS.	No.
1	Steel . . .	. . .	. . .	At 31,460 pounds pulled thread from nut.	1
2	Steel 10,360	. . .	. . .	Broken diagonally through three threads.	2
3	Steel 6,790	. . .	. . .	Broke through base of one thread.	3
4	Steel 7,800	. .	. . .	Stretched in all exposed threads.	4
5	Steel 12,290	67,957	115,636	Broke with cupped fracture.	5
6	Swedish 4,742	43,072	117,000	Fracture with fine fibre.	6
7	Iron H. 18,110 Track I	57,145	83,156	Broke with oblique fracture	7
8	Iron H. 17,510 Track I	51,969	63,673	Broke at shoulder.	8
9	Iron H. 10,430 Track I	63,645	33,512	Broke close to nut.	9
10	Swedish 34,460 Same Bar a	43,468	125,312	Fracture with fine fibre.	10
11	Steel 54,004 Same Bar a	68,915	150,035	Fracture cupped partly in each end.	11

RECORD OF TESTS MADE BY SUB-COMMITTEE NO. 1,403 ON SIMONDS' ROLLED FORGING MACHINE.

No.	MATERIAL.	DESCRIPTION.	FORM BEFORE TEST.	FORM AFTER TEST.	SQUARE INCHES AREA.		Per Cent. Reduction in Section.	LENGTH IN INCHES.		Pounds Breaking Strain.	Pounds Strength per Sq. Inch. Original Section.	Pounds per Sq. Inch. Final Section.	REMARKS.	No.
					Before Test.	After Test.		Before Test.	After Test.					
1	Steel.	Simonds' Track Bolt			...	...	...	...	...	...	...	...	At 31,460 pounds pulled thread from nut.	1
2	Steel.	Simonds' Track Bolt			328	Too irregular for measurement.	...	...	...	34,600	...	...	Broken diagonally through three threads.	2
3	Steel.	Simonds' Track Bolt			328		...	...	...	27,290	...	...	Broke through base of one thread.	3
4	Steel.	Simonds' Track Bolt			328		...	...	...	21,800	...	...	Stretched in all exposed threads.	4
5	Steel.	Simonds' Track Bolt.			328	151	53	4'17	4'85	21,900	67,957	115,636	Broke with cupped fracture.	5
6	Swedish Iron.	Simonds' Track Bolt.			343	126	703	4'16	5'17	14,042	43,072	117,000	Fracture with fine fibre.	6
7	Iron H. & T Track Bolt	Head Upset			337	217	33	4'21	4'67	18,110	57,145	83,156	Broke with oblique fracture	7
8	Iron H. & T. Track Bolt.	Head Upset.			317	275	19	4'21	4'67	17,510	51,069	63,673	Broke at shoulder.	8
9	Iron H. & T Track Bolt	Head Upset.			340	617	103	4'15	4'38	17,430	63,645	33,512	Broke close to nut.	9
10	Swedish Iron. Same Bar as No. 6.	Straight Bar Turned Down.			703	270	65	...	...	24,460	43,468	125,312	Fracture with fine fibre.	10
11	Steel. Same Bar as No. 5.	Straight Bar Turned Down			798	365	54	...	...	54,014	68,915	130,035	Fracture cupped partly in each end.	11

The nuts used in the above tests are Hoopes & Townsend's cold-punched iron hexagon.

that they feel it incumbent upon them to report what they find to be the preceding state of the art under which this invention was made, in order that the position which this improvement is entitled to claim may be clearly appreciated.

They find, as is, frequently, if not invariably the case, preceding embryonic inventions and attempts at analogous results.

In none of these does this invention, when clearly understood, appear.

In making this search, your committee have inspected the classified series of patents in the United States Patent Office relating to this subject-matter directly, and all that the examining corps of that office thought in any degree collaterally pertinent to the subject, in examining Mr. Simonds' several applications for patents, and of every patent cited as a reference bearing upon the subject; they have, in turn, examined all patents and other references cited as bearing upon these, both foreign as well as American.

Whilst your committee are fully aware that this extent and line of examination by them is unusual, they feel that it is due to the importance of the invention, and the place it must, by its merit, occupy in the arts.

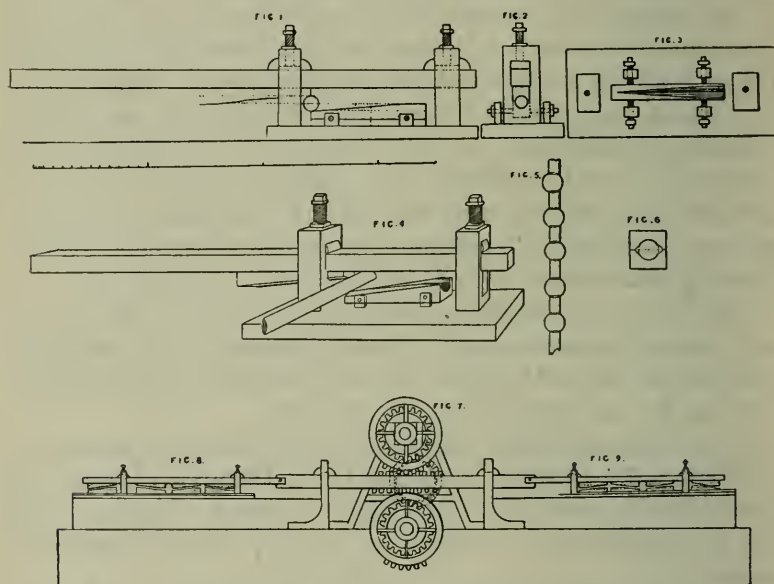
The references thus collated, with the thirteen patents of Mr. Simonds', include forty-five United States patents and nine British patents, a schedule of which, together with other publications referred to, will be found appended hereto.

It is scarcely necessary to add that many of the references cited did not relate to the method or any essential principle or feature involved in the invention, but merely to minor details in the construction of the apparatus.

From this examination your committee find, as a pre-existing state of art, a number of attempts to produce articles of circular form by rolling.

Earliest of these is that shown in the British patent No. 2,932, dated October 30, 1806, granted to William Bundy, a mathematical-instrument maker, of London, for a machine for making bullets.

In this machine the lower die was trough-shaped and stationary, while the upper die was of a similar form, and arranged to slide in dies lengthwise over the lower one. These dies were bevelled or inclined in the direction of their length, but straight or parallel crosswise upon their edges. The lead to form the bullets was introduced between the dies in the form of a cylindric bar, laid across the lower die at the lower end, and the edges of the upper die passing over it, pressed upon the lead and forced it upon the edges of the lower die, along which it rolled to the opposite end,



Bundy's British Patent No. 2,932, of 1866.

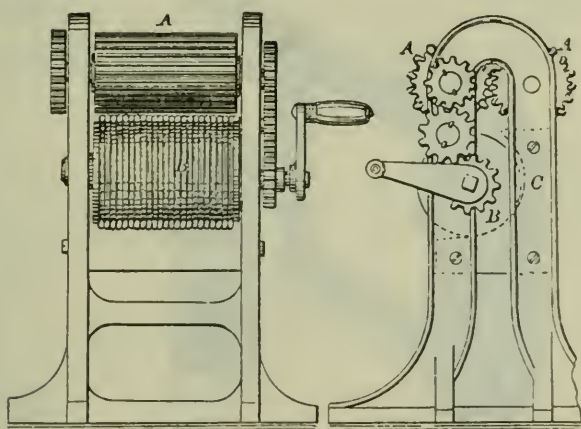
crushing it between the parallel edges of the dies, the portion, in the semi-circular trough of the dies, assuming a spherical form, and the part between the parallel surfaces of the edges acquiring a cylindric form, which was gradually reduced in diameter, until severed from the ball, leaving prominences on the poles of it.

The end view of the dies shows that the dies did not make perfect spheres, but instead balls with projecting lumps at the poles, which were to be afterward rolled down to conform to the spherical surface.

The drawing shows the balls as partially formed and united by the cylindric stem or bar; the dies in this case did not push the metal outwardly from the sphere, but pressed radially inward, forcing the metal toward the sphere, and differ from those of the Simonds inventions which force it outward.

This machine, while bearing some resemblance to that of Mr. Simonds, worked imperfectly in lead and was inapplicable to iron.

Bruff's bullet compressing machine, which we here reproduce as illustrated in Knight's *Dictionary of Machines*, vol. 1, page 403, made leaden spheres, by rolling

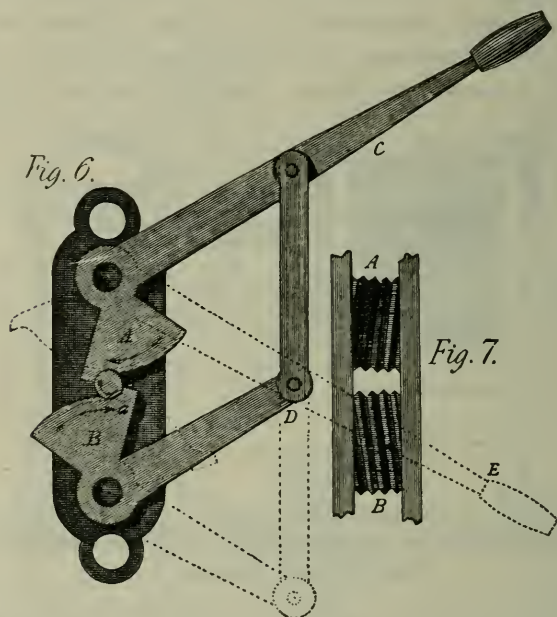


Bruff's Bullet Machine.

cylindric bars of lead between a circumferentially-grooved revolving cylinder and a converging concave surface having corresponding grooves. In this case, the lead is compressed lengthwise in the direction of the axis of the bar, so that the diameter of the bar required was less than that of the resulting sphere. The metal, in spheres compacted by this machine, was not subjected to as much pressure at the central band as at the poles. In this device the metal is compressed and shortened in the direction of the axis of the bar, and enlarged diametrally, which is the reverse of the operation of the Simonds rolling dies. Neither of these inventions appear to have been applied to other materials

than lead, and while having some semblance to the invention under consideration, are essentially different, and do not contain the invention under consideration.

In a publication, dated 1822, Manchester, England, entitled *James White's New Century of Inventions*, there appears on plate 19, in *Figs. 6 and 7*, and described in pages 60 and 61, a machine or hand implement, designed to roll circular objects including screw threads. A copy of the drawing is here



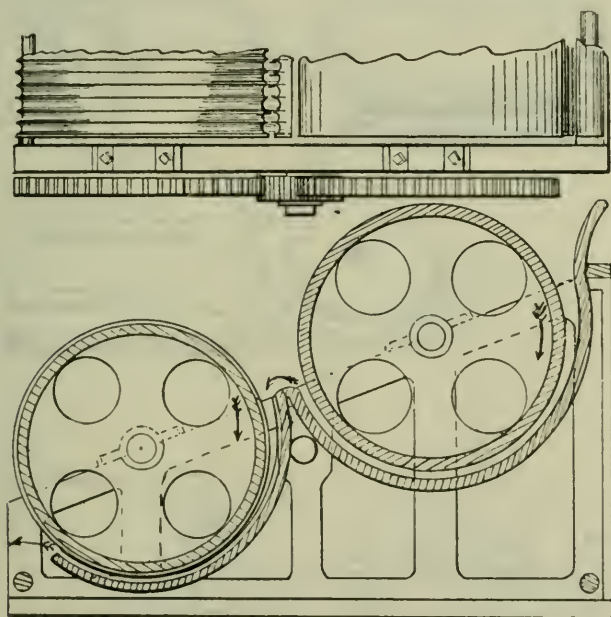
Jas. White's Rolling Machine, Manchester, Eng., 1822.

shown. A full copy of the text of his description will be found in the appendix to this report.

While this recognizes the fact that screw threads diverge as they are rolled, it fails to show that the lengthening of the article to shape must be accomplished by a bevel on the edge on the working faces; in fact, it shows nothing more than two parallel involute faces, opposed to each other, and vibrated simultaneously by a lever handle and connecting links, the section showing threading grooves. The inventor does not appear to have ever made or tried the device, but

simply described it and suggested applications of it in the arts.

Machines operating similarly to Bruff's, made by the late Reese J. Hollingsworth, machinist of this city, and known as "pill" machines, have been in use in the cracker bakeries of Philadelphia since 1852. These were used to make balls of dough with a rolled "skin surface" from which water crackers were made. A partial top view and vertical section is here shown.



Hollingsworth's Pill Machine, 1852.

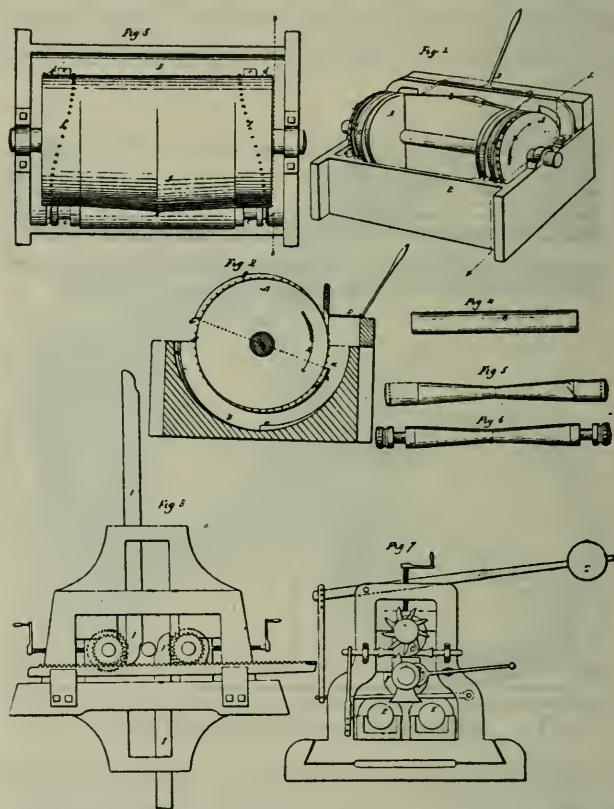
It is obvious that the cylinder of dough, from which the spheres are cut and rolled, is longer than the sum of the diameters of the balls produced from it, and is of less diameter than the balls, requiring an upsetting or shortening to form the ball, and in this respect it differs from the Simonds machine in principle.

While the materials operated on in these machines are so different from iron and steel, the resemblance of parts used is considerable and suggestive of the constructions used for metal working; in fact, the practice of mechanics in making

WHOLE NO. VOL. CXXVI.—(THIRD SERIES, Vol. xcvi.)

models of machines for rolling, forging and stamping ductile metals is to test them when in course of construction, with clay, dough, wax, putty and lead.

Having these machines in view and such practice in mind, the resemblance of the invention described and shown in United States Letters-Patent No. 10,460, dated January



Jacob Reese's U. S. Patent, No. 10,460, of 1884.

24, 1854, for rolling axles and shafts, granted to Jacob Reese, becomes apparent, as will be seen in the drawing which is here shown.

Here is a showing of oppositely moving reciprocating tables; three rollers between which an axle was to be placed and means for pressing the upper roller down and convex series of dies turning in concave series, which are

described as "converging" and "properly shaped," but they lack the necessary inclination of the edges of the working faces to draw the metal, being in fact converging profiles fitting the shapes of parts of the desired axle.

Such converging faces being parallel with each other in the direction of the axis of the bar, could only press radially upon the bar, and have been demonstrated to be incapable of useful operation.

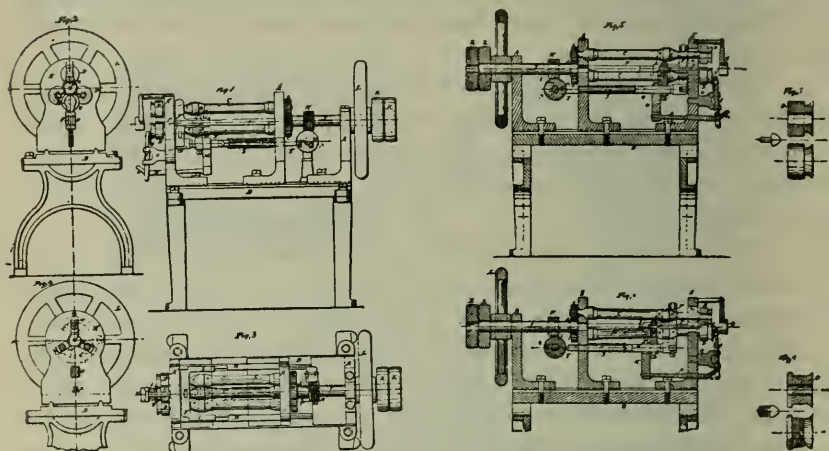
The breadth of the die surfaces is equal to that of the surfaces they are to swage or roll throughout their entire length, and therefore could not gradually develop the reduction of diameter and extension in length as is done in the Simonds invention.

It is noticeable in the Reese patent that the bar is intended to be carried and guided by lines of projecting points which, indenting the metal, compelled it to roll between the swaging surfaces. These are so located as to hold in parts of the bar beyond the length of the axle, which were afterward to be cut off. It does not appear that the Reese invention was ever reduced to practice; as described and shown it could not have been, but from its plausible resemblance it seems entitled to notice as a part of the preceding history of the art.

The reducing of metallic rods diametrically by rolling to form rivets, is shown in United States Letters-Patent to Charles B. Allen, of Philadelphia, numbered 22,843, and dated February 8, 1859, the drawing of which is here shown.

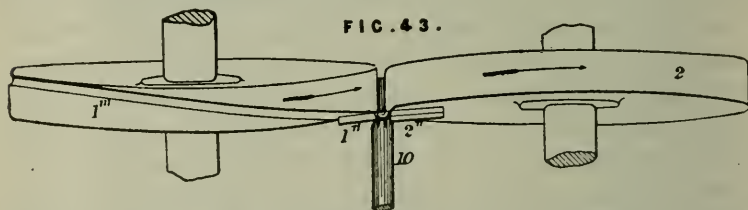
In this machine, a rod, equal in diameter to the greatest diameter of the intended rivet head, was reduced by rolling between three equi-distant revolving rollers, which were gradually pressed toward the axis of the bar, the form of the rollers being a profile of the rivet. The rivet when formed was severed from the rod by a revolving cutter, or circular saw pressed against it. The extension of the metal in this machine was due entirely to the diametral pressure made upon it, and not to any direct drawing process, the compression to reduce the diameter being made throughout by the same instrument that finished it. This invention was slow in operation and never attained a permanent place in

the arts. Among the later inventions that have been suggested as resembling that of Mr. Simonds, is that shown in British patent No. 3,677, dated December 20, 1869, granted to James Robertson, of Glasgow, Scotland, for rolling balls and rivets from rods. In this two rollers, placed with their



C. B. Allen's U. S. Patent, No. 22,843, of 1859.

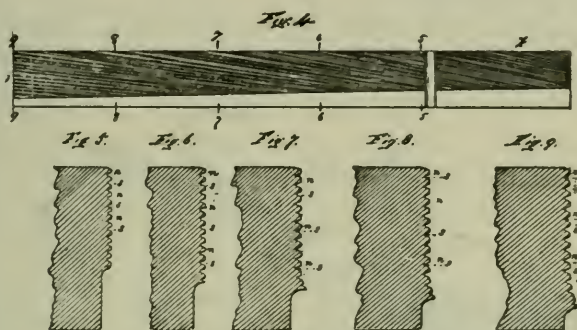
axes slightly inclined from parallel position with each other, were turned and grooved upon the face, so that the space between them was of the same form and size as the lengthwise central section of the desired forging. The wheels were rotated in opposite directions.



Robertson's British Patent, No. 3,677, of 1869.

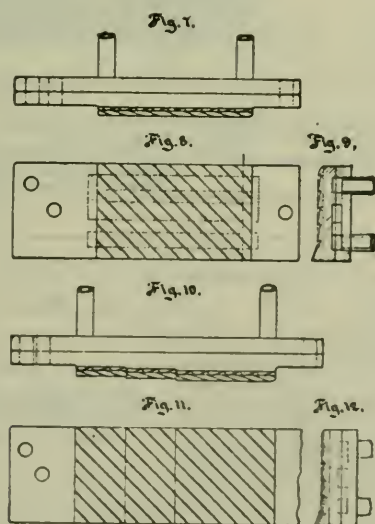
The action of this apparatus was almost entirely by compression in the direction of the diameter of the rod, the drawing or stretching effect due to the inclination of the axes of the wheels being very slight, this invention does not appear to have reached any commercial success.

Among the patents referred to, as recognizing the extension in length during the rolling operation between dies, is Edward Croft's re-issued United States patent No. 5,673.



E. Croft's U. S. Patent. Re-issue, No. 5,673.

dated December 2, 1873, which shows dies with diverging oblique ridges and grooves, shown in the figure marked 4, copied from that patent, but no attempt was made to give

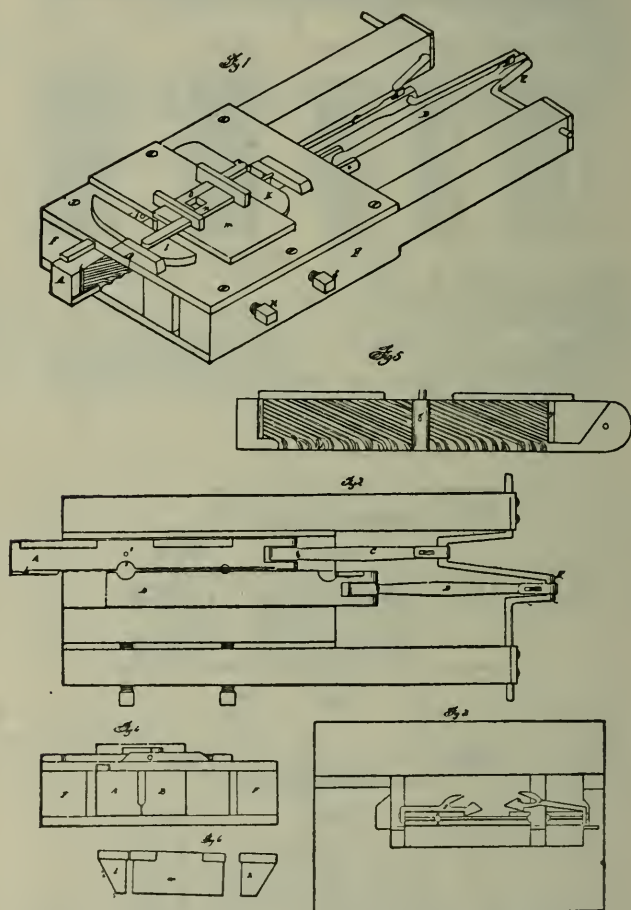


J. M. Alden's U. S. Patent, No. 110,532, of 1870.

any other shape to the articles by rolling, but stopped at simply impressing threads upon them. Dies, for hot rolling threads upon iron screw blanks, also appear in J. M. Alden's

United States patent, No. 110,532, dated December 27, 1870, for wood-screw machine, figures numbered from 7 to 12, which are here shown.

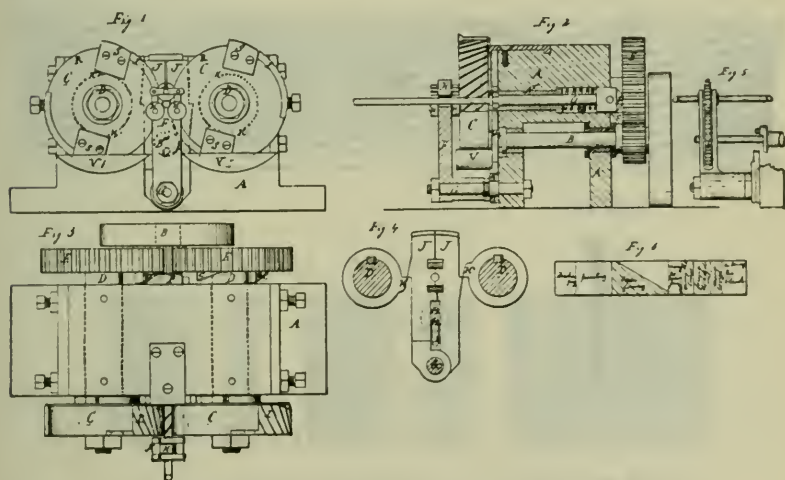
The angle of inclination of the threading ridges is uniform. The portion which makes the tapering threaded point



Harwood and Mickle's U. S. Patent, No. 72,490, of 1867.

of the screw is described as cutting the metal away to make the taper, by the sharp end of the die shearing the metal off as the die swages a part, and cuts off a part before rolling the point, the pressure at the end in these dies tending to shorten or upset the metal.

An earlier United States patent, that of Harwood and Mickle, numbered 72,490, and dated December 24, 1867, illustrated opposite, shows dies for threading screws, having oblique grooves and ridges between which the screws were rolled, and with the ends of the grooves and ridges carved, so as to produce a greater pitch in the threads of the screw at the point, to facilitate the entrance of the screws into wood. The resemblance in this machine to that of Mr. Simonds ceases with the indenting of the thread; there is in it no pretence of drawing or stretching the metal, but simply indenting it.



R. Boeklen's U. S. Patent, No. 109,171, of 1870.

R. Boeklen's United States patent No. 109,171, dated November 15, 1870, the drawing of which is above shown, simply impresses screw threads upon cylindric rods, by rolling them between spirally-grooved cylindric rollers, with their contiguous faces turning in opposite directions on parallel axes. The screws, thus made, have heads formed on them by upsetting the rod in the usual manner for making rivet heads; this, like the preceding device, only resembles the Simonds invention in rolling the screw threads, instead of cutting the metal from between them.

In the invention of Clark and Harvey, shown in United States Letters-patent, No. 306,132, dated October 7, 1884, the

account of his conception and development of this invention is given, that it would be a trespass upon patience to restate it in this report. After a careful examination of the invention and all collateral information seeming to bear upon the subject within reach of your committee, they are fully warranted in the conclusion that the entire credit of originating and perfecting the method or system herein described, of metal forging by rolling shapes, without impairing the quality of the work by upsetting, belongs to Mr. Simonds, and that the high degree of perfection to which he has brought this new art, both in facilitating production and in improving the product, fully entitles him to recognition by the highest award in the gift of the FRANKLIN INSTITUTE, viz: the ELLIOTT CRESSON MEDAL.

Respectfully submitted,

S. LLOYD WIEGAND,

J. SELLERS BANCROFT,

HUGO BILGRAM,

JOHN H. COOPER,

L. L. CHENEY.

Adopted October 3, 1888.

GEORGE A. KOENIG, *Chairman.*

THE RELATIVE VALUE OF ALUMINIUM AND ITS ALLOYS IN THE ARTS.

(A CORRECTION BY MR. PEMBERTON.)

In the article on "Aluminium and its Alloys," published in the October impression of this JOURNAL, the statement was made that the United States Government had countermanded the order for manganese bronze for the construction of propeller blades, and had adopted aluminium brass in its stead. This statement was taken from a letter, by Mr. Eugene H. Cowles, to *Engineering*, appearing in its issue of June 1, 1888. As a matter of precaution, however, the entire paper on the subject was submitted to Mr. Alfred H. Cowles, but, unfortunately, owing to his absence from Lockport, did not reach him early enough to allow him time to

reply before publication. He writes me that the Government has "accepted our No. 3 aluminium bronze for this purpose, but still leaves the contractors free to use manganese bronze if they so desire. It results in our having to furnish the aluminium bronze with very high strength specifications in competition with manganese bronze with no strength specification stipulated, and at the same price. We are now making the wheel for the gun-boat *Petrel*."

H. PEMBERTON, JR.

ON THE DISTRIBUTION OF INTERNAL FRICTION OF ENGINES.*

BY ROBERT H. THURSTON, Ithaca, N. Y.

INTRODUCTION.

In earlier papers, read at various times before the American Society of Mechanical Engineers, the writer has called attention to the fact that the variation of load in steam-engines is not productive either of the method or of the amount of engine friction that has been commonly assumed by earlier authorities on that subject.† It was shown that the formula of De Pambour, which makes the internal friction of the engine proportional to the load on its piston is not usually correct, and probably is never so, with any familiar form of engine, or under any conditions often met with in practice. It was further shown that, under the conditions of usual practice, and at all ordinary speeds and pressures of steam, the resistance of the engine itself, its internal friction, remains sensibly constant, and that the so-called friction-card of the machine represents practically the friction of the engine when fully loaded, the indicated power without load being sensibly the measure of the

* Read at the Scranton Meeting of the American Society of Mechanical Engineers, October 15-19, 1888.

† "Friction of Non-condensing Engines." *Trans.* Vol. viii, No. ccxxviii and Vol. ix, No. cclxv.

wasted work of the engine when in operation under load of whatever amount.

The literature of this branch of the subject of steam engineering is very meagre, and the results of experiment in this field, if any have yet been systematically made, are not recorded in any works as yet consulted by the writer. The very natural supposition that the friction of an engine is always composed of two parts, the one the friction of the engine unloaded, a constant, and the other a quantity measuring the added friction due to the imposition of the load, and variable directly with that added load, seems to have been accepted by all writers from De Pambour, the first to attempt to consider the subject, to the period of investigation by the writer. On the other hand, however, engineers familiar with the operation of the engine have been accustomed to take a diagram with the steam-engine indicator, the engine being unloaded, as representative of the friction of the machine at all times. This was probably taken as so representative simply because it was usually impossible to obtain any measure of friction of loaded engine, and the friction-card was thus the best approximation that could be secured. Rankine would seem to have suspected that the assumed formulas of De Pambour might not be exact, as he remarks, "Our knowledge of the amount of energy so lost is still very vague and indefinite;" but he also states (*Steam Engine*, art. 292) that "in most cases which occur in practice, a result nearly agreeing with that of the preceding formula, is obtained by supposing that the whole of the prejudicial resistance is proportional to the useful load." De Pambour gives the value of the coefficient by which the load is multiplied as about 0.14, and Rankine asserts this to agree with practice. Weisbach attempts to produce a formula for this waste, assuming Morin's values of coefficients of friction, but his results are very greatly in excess of those to be given as determined by investigations made to ascertain its amount by experiment: they also seem to be based upon entirely inaccurate assumptions, and are evidently quite as unreliable as are those of De Pambour and Rankine.

The first investigation undertaken systematically to determine the law and the methods of waste by internal friction in the steam-engine were, so far as yet known, those directed by the writer, the scheme being the securing of constant conditions, except in the one direction in which variation was to be produced, for the purpose of noting the extent and the law of variation of friction with variation of the one element studied. Thus: the engine was placed under the usual and standard working conditions, but without load, and a friction diagram was taken as a measure of the power wasted in friction of engine alone. The conditions being kept constant in all other respects, the load on the engine was varied from this minimum up to and beyond the maximum rated power of the machine, and the indicated compared with the dynamometric power in every case, the difference measuring the engine friction for that power and load. In other cases, the speed of the engine varied, the power and all other conditions being kept constant; the same method applied when the power, speed, steam pressure and other conditions were held constant, except that the method of distribution of steam was varied, and the results of such a series of tests were then compared with those otherwise obtained. In still other instances the steam pressure was made the variable element, or the ratio of expansion and point of cut-off, the indicated and dynamometric power being in each case compared as before to obtain a measure of the engine friction. By this systematic method it was anticipated that in time a correct theory and exact formulas might be produced. This expectation has not been wholly disappointed; but the results of the investigation, while eminently satisfactory, have proved to be quite opposed to the original assumptions of the older writers, and in most perfect accord with those of the practitioners.

The first of these series of experiments to be made in so satisfactory a manner as to justify publication, were those conducted under the supervision of the writer, in the winter and spring of 1883-4, by Messrs. Aldrich and Mitchell, and published in a paper read before the American Society of

Mechanical Engineers in the autumn of 1884.* The engine employed was a Straight Line Engine, constructed under the eye of its inventor, Professor John E. Sweet, past President of the Society, and representing well that type of engine. These experiments showed unmistakably the error of the older formulas, and revealed the unexpected fact that, in that class of engines at least, the internal friction does not vary with the addition of load, but remains constant, so far as could be detected, at all loads. The method of lubrication and its efficiency, the variations of steam pressure and of speed, slight as they were, were accidental causes of change of engine friction, having very much greater effect on the total than a variation of the power of the engine from that marking its resistance to motion, unloaded, up to the full rated power of the machine, and even far beyond the latter amount. The engine had been carefully designed with the special intent to make engine friction as low as possible, and the loss by friction at its rated power was but about six per cent. It came down to about five per cent. at the maximum power demanded of it, varying almost precisely in inverse proportion to the indicated power. The "friction-card" was a measure of the friction of the engine at all loads.

This research was again undertaken at the request of the writer, in the winter and spring of 1885, by Messrs. Day and Riley, of Sibley College, Cornell University, employing a similar engine, built under the supervision of the inventor in the workshops at that school. The outcome of these investigations, which have also been recently fully reported and widely published in this country and in Europe, was thoroughly corroboratory of the previous conclusions. No measurable variation of the total internal friction of the engine could be traced to the variation of engine power and load. Studying the effect of variation of steam pressure, it was found that some slight alteration was produced, the friction increasing very slowly as pressures were increased, but not in any important degree. These data have been since revised by Messrs. Carpenter and Preston, and it has

* *Trans. A. S. M. E.*, Vol. viii, page 86.

been found that the change of friction with variation of steam pressure may be taken as insensible after passing the ordinary minimum working pressure of engines, the variation being observable only from about fifty or sixty pounds per square inch downward. It having been also suggested that the method of steam distribution might produce some change in the law exhibited by the types of engine having automatic adjustment of expansion by the action of the governor, Messrs. Gillis and Buchanan, in 1887, undertook, under the direction of the writer, to settle this question by experiments upon the engines of similar type, as employed in the mechanical laboratories of the Sibley College. These experiments fully confirmed those which had previously been made, and showed sensibly constant friction at all powers and loads, whether the engine was regulated by the automatic system, or by a governor operating the throttle-valve in the steam-pipe or at the steam-chest.

We are now brought to the study of the latest, and as yet unpublished, experiments made to determine, with some degree of exactitude, the *method of distribution of internal friction*, and, further, to ascertain whether all engines are subject to the same law as has been found to control the high speed engines previously employed in these researches. These last investigations were made with this object in view by Prof. R. C. Carpenter, of Lansing, Mich., and Mr. G. B. Preston, of Sibley College, as observers, experimenting first with the engines of the college laboratories, and later with other machines of various types in and near Lansing. Earlier experiments had shown the engine friction to be independent of the load, but to be a function of the characteristics of the engine itself, of the speed of piston and rotation, of the steam pressure, and of the method of steam distribution, the two last-named conditions having slight effect, the others being most important. The weight and design, and the character of the workmanship of the engine, primarily determine the amount of its internal friction; the resistance is also a direct function of its speed, and it is slightly and observably affected, within limits, by the steam-pressure variations, and by the character of valve-gear and

of steam distribution and of regulation of engine. The speed and weight of the running parts of the engine may, so far as can now be ascertained, be taken as the elements controlling friction of the machine. The details of all this earlier work have been given at sufficient length in the earlier volumes of the *Transactions of the American Society of Mechanical Engineers*.

It now becomes an interesting and a vitally important problem to determine just how this friction of engine is distributed among its various moving parts, its journals and guides, stuffing-boxes and piston-rings. This has hitherto been regarded as a problem incapable of solution, since it was presumed that the total and the elements of the internal friction of engine would be so seriously variable with the alteration of load, that it would be impossible to measure the friction of the machine, part by part, and to sum up the whole correctly. It having been found, however, that the internal friction of the engine is invariable in any measurable or important degree with variation of power, and that the so-called "friction-card" is a measure of the friction of the engine at all powers, the speed being constant, it is at once evident that we may now proceed to analyze the several parts of this total by analyzing the engine into its various friction-producing elements, and measuring up the several elements of the total friction, each by itself, and summing all for the total. The discovery of the sensible constancy of the total friction thus affords a new means and method of investigation. This accomplished, also, it becomes possible, knowing as we now do, the quantities of friction at each point of "pairing" of elements, as Reuleaux would say, and it becomes easy to determine just where the most serious wastes of energy and power are met, and thence, just in what direction we are to study the design and construction of the machine with a view to the reduction of these wastes most promptly and effectively. The improvement of the efficiency of the steam-engine is to be now effected very largely by its improvement as a piece of mechanism, and nearing, as we now are, the limit of the perfectibility of the engine thermodynamically, the engi-

neer is compelled to look in this direction for further opportunity of advancement. The thermodynamic efficiency of the engine has attained, in the best of modern engines, very nearly its maximum under familiar working conditions; the efficiency of the engine as a machine still offers some little chance of gaining upon the existing conditions of best work. The thermodynamic wastes are now by the best designers and constructors reduced to about ten per cent. in large engines, while the friction wastes of the machine are usually considerably more in that class of engines, though less in the simpler and lighter engines of the recent high-speed type.

The plan adopted in the series of experiments to be described, in which Messrs. Carpenter and Preston proposed to endeavor to effect an analysis of the total internal friction of the steam-engine, and to ascertain in what proportion it is distributed to piston and cross-head, crank-pin and shaft, valve-gear and guides, was first to determine the friction of the machine in the manner already practised by them and by their predecessors in this work, then to dismantle the engine, part by part, driving the connected parts by a pulley and belt from the main line of shafting overhead, through a transmitting dynamometer carefully standardized, and thus to secure measurements of the resistance of part after part until all the rubbing parts having been thus examined, the sum of their resistances at the normal speed of the engine should give the total internal friction of the engine and the percentages of the whole due to the resistances of each point of connection or rubbing. In each experiment the endeavor was made to secure precisely the conditions of operation, so far as was practicable, which were usual in its regular working. For instance: the engine was always heated up by its own steam when the resistances of the piston and the valves were to be measured; the speed of engine was kept the same when testing the friction of journals as when it was doing its full work; the valve, balanced and unbalanced, was tested under the usual boiler pressures, as well as unloaded, and exactly as possible, and thus every precaution that could be devised was adopted to secure

precisely the results that should be observed, were such observation possible, when the machine was at work. The engine was first driven by the shafting, and through the dynamometer, with everything connected and the cylinder heated up to its usual temperature by a run, immediately preceding, under steam, the cylinder heads and steam-chest cover only being removed to prevent any pump-like action of the engine while so driven. Next, the piston was disconnected, and the power demanded to give the engine its regular speed was observed with all other parts connected and moving; thus obtaining a measure of the friction of the piston alone, by differences. Then the next point of connection would be broken, and another observation would give the friction of the next successive piece, and so on until the whole engine had been gone over, when the machine was assembled again, part by part, and thus a check obtained on the previous determinations.

The first step of importance was to secure a good standardization of the transmitting dynamometer to be employed in the work. This method required the use of a transmitting dynamometer of great accuracy. Sibley College possesses a number of such dynamometers, the accuracy of each of which was tested by comparison with a Prony brake, and also by lifting a known weight through a given space. The best result was given in each case by a dynamometer of the Morin type, built in the Sibley College shops. The principle governing its action is very simple, and is shown clearly in *Fig. 18*. A pulley of which the rim *B* is shown, is fitted loose on the shaft *S*. Four flat springs are securely bolted to the shaft *S*, and to the rim *B*. Now, if force be applied by a belt around *B*, to turn the pulley, and if resistance to its turning be produced by a fixed pulley on the shaft *S*, from which some machine is driven by the belting, the springs *c* will be deflected into new positions *c'*, an amount proportional to the force, and the fixed pulley will then revolve, thus driving the machine. To show the amount of power transmitted, and any variation that may occur in that power, a pencil is attached to the rim of the pulley, or to a post having an equivalent

motion, and a recording apparatus, consisting of a series of gear-wheels actuated by a spiral thread on a sleeve on the axis, causes a band of paper to move radially under the pencil. The recording apparatus can be stopped or started at will, without interfering with the motion of the machinery, by causing the loose sleeve to engage with a lug on the shaft. The results obtained with this dynamometer agreed closely with those results obtained by the Prony

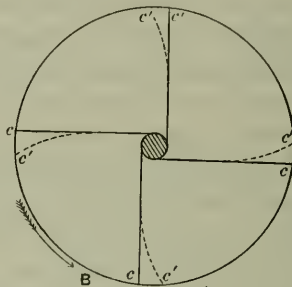


Fig. 18.

brake, and by moving a known weight through a given space. The diagrams obtained from the dynamometer consisted of a series of waving lines of varying elevation and with different average ordinates. The undulations were produced by changes of speeds probably caused by the inequalities of belt lacings, etc.

The general appearance of these diagrams is shown in Fig. 19.

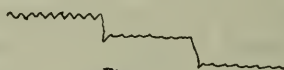


Fig. 19.

The dynamometer was calibrated three times: (1) By attaching a brake to the same shaft, and comparing the diagrams with the brake readings. (2) By direct pull with a spring balance against the springs of the dynamometer and thus obtaining the ordinate for a given belt-pull. (3) On the same principle as the first, but a spring balance was used, to measure the brake weights, instead of scales. The object of these calibrations was to obtain the ordinate.

corresponding to any given belt-pull. The following results were obtained:

CALIBRATION OF DYNAMOMETER.

Comparison with Prony Brake.

First Trial—Brake pulling against load of 52 pounds on Fairbanks Scale.

Scale Load.	Brake Load. Pounds.	Pull on Dynamometer Pulley.	Ordinate in Inches.
2	50	67.1	3.10
6	46	61.7	3.00
11	41	55.0	2.90
16	36	48.3	Lost.
21	31	41.6	2.06
26	26	34.9	1.75
27	25	33.5	Lost.
31	21	28.2	1.57
36	16	21.5	1.30
41	11	14.8	1.25
52	0	0.	0.4

Second Trial—Brake pull measured by a spring balance.

5	6.7	0.54
10	13.4	0.92
15	20.1	1.23
20	26.9	1.55
25	33.6	1.80
30	40.3	2.16

The diameter of the brake pulley, including belt, was $23\frac{1}{2}$ inches; the dynamometer pulley, including belts, was $17\frac{1}{2}$ inches.

CALIBRATION ON DYNAMOMETER.

(2) Method, by direct pull against springs of dynamometer.

This method was employed a number of times, and gave uniform results, the variations from the results of this trial and the first and third, as previously given, are believed to be errors incident to the use of the brake.

Pull on Dynam. Pulley. Pounds	Ordinate Inches.	Pull on Dynam. Pulley. Pounds.	Ordinate Inches.
0	0.40	35	1.80
5	0.65	40	2.08
10	0.80	45	2.32
15	1.02	50	2.58
25	1.33	60	3.08
30	1.55	70	3.52

The mean of these three results corresponds very closely to this last, and, where plotted, gives a straight line, whose equation is

$Y = 0.046 + 0.20X$, Y being expressed in inches and X in pounds.

The diagram of the curves is shown, and interpreting the results was used instead of the equation. (See *Fig. 20.*)

The engines employed in the investigation to be described were of several types and of various sizes, styles and proportions. The first was a small straight line engine, built in the Sibley College workshops, but modified from time to time for purposes of experiment, in such manner that it represented the ordinary type of directly connected engine with throttle regulation. It was tried, both with its usual balanced and with an unbalanced valve. Another engine was a traction engine, built by the Lansing Iron Works, with locomotive style of valve motion; and others,

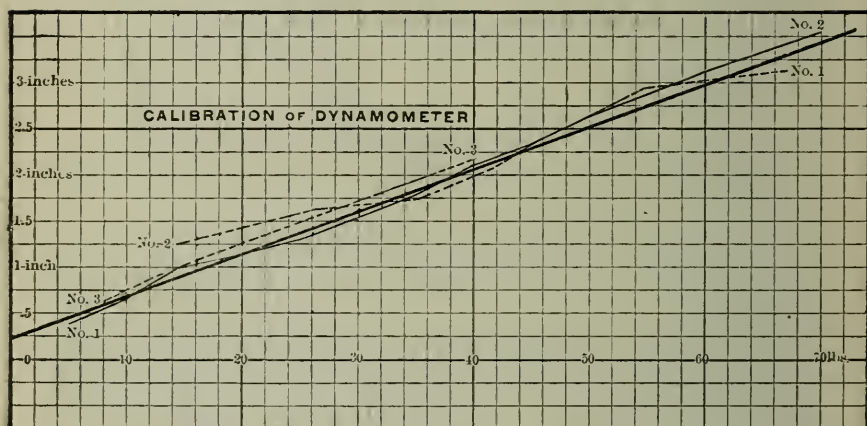


Fig. 20

by the same company, were of the automatic type, and compound and condensing engines, both the latter having balanced valves.

FRICTION OF STRAIGHT LINE ENGINE.

The first engine tested was the 6 x 12-inch straight line engine built by Prof. J. E. Sweet, while connected with Sibley College. This engine has been modified for experimental purposes in many ways, but still retained the principal characteristics of the straight line engine. The valve-gear is arranged for a fixed cut-off at any part of the stroke less than five-eighths, and the valve can be changed by

removing the pressure-plate and fastening on a back, from a balanced valve to an ordinary slide-valve.

For these tests the power was obtained from the water-wheel and main driving shaft in the Sibley College shops, the speed of which was not always uniform and was beyond the control of the investigators. The power was measured by passing it through the transmitting dynamometer. The speed was measured by a hand-speed indicator and also by an attached tachometer, which had been carefully calibrated. The tachometer results could only be used to correct errors, as readings to single revolutions could not be made.

In making this trial, and all others, the engine was first heated up by steam, the steam-chest cover and cylinder-heads were removed to prevent pump action, then, as quickly as possible, the dynamometer cards were taken. These diagrams were generally taken with the engine complete, and then successive cards with part after part removed. The engine was turned by power applied to its main driving-wheel. The speed of the engine varied from 200 to 244 revolutions, and the results were corrected in accordance with the law, known to be true for that engine, that the friction varied directly as the speed. This correction, however, did not seriously change the results. Twenty-nine successful dynamometer cards were obtained, each of which may be considered as the average of several observations. The practical condition of working of a plain slide-valve, with steam on, could not be obtained in these trials, because the cylinder was open to the air, and the friction obtained is no doubt too high for that particular case.

Table I presents a record of the distribution of friction found in this engine, and all essential data from later comparisons with other results from tests of the various engines afterward employed.

Table II exhibits the method of variation of friction, and Tables III and IV its computed amounts.

TABLE I.—DISTRIBUTION OF FRICTION.

Straight Line Engine 6" x 12". Log of Trial with Morin Dynamometer.

Number.	Ordinate.	Pull in Pounds.	Revolutions per Minute.	H. P. Developed.	H. P. : Revolutions.	H. P. Corrected for 230 Revolutions.	Steam Pressure in Engine.	CONDITION OF ENGINE.
1	1'78	34'5	208	1'556	'007	1'710	0	Engine Complete. Warmed up by steam. Cylinder-head off Steam-chest cover and pres- sure-plate off. All cocks open
2	1'87	36'5	205	1'622	'008	1'822	0	
3	1'86	36'5	205	1'622	'008	1'822	0	
4	1'20	22'5	230	1'122	'005	1'122	0	Piston and piston-rod dropped.
5	1'25	23'25	232	1'169	'005	1'159	0	
6	1'27	23'8	244	1'259	'005	1'189	0	Pressure-plate and steam-chest cover replaced.
7	1'28	24'0	245	1'275	'005	1'200	40	
23	2'04	39'0	186	1'573	'008	1'925	45	Balanced valve converted into slide-valve. Steam pressure on back of valve.
24	1'90	37'0	186	1'492	'008	1'844	45	
25	1'82	35'0	201	1'525	'007	1'728	42	
26	1'81	35'0	214	1'624	'008	1'752	39	
27	1'92	37'5	201	1'634	'008	1'868	37	
28	1'67	34'0	217	1'599	'007	1'690	74	
30	1'19	22'5	229	1'117	'005	1'112	0	Slide-valve, piston and rod still off.
31	1'80	34'75	218	1'642	'0075	1'732	74	
32	1'07	19'5	205	0'867	'004	0'967	0	Main shaft and eccentric.
33	1'03	18'5	207	0'830	'004	0'922	0	
34	1'00	17'5	228	0'865	'004	0'873	0	Eccentric-strap made as loose as possible.
35	0'95	16'5	225	0'805	'004	0'825	0	
36	1'10	19'5	227	0'960	'004	0'972	0	{ Connecting-rod attached to crank-pin.
39	1'26	23'0	215	1'072	'005	1'147	0	Engine complete except piston and rod. Slide-valve attached. Cylinder hot.
40	1'84	35'0	198	1'502	'008	1'758	75	
41	1'29	24'0	222	1'155	'005	1'195	0	
42	1'92	37'5	211	1'715	'008	1'867	67	
45	1'24	23'0	223	1'112	'005	1'147	0	{ Slide-valve dropped. Valve- rod still attached.
47	1'39	26'0	222	1'251	'006	1'299	0	Balanced-valve. Pressure-plate and cover off.
48	1'28	23'5	220	1'121	'005	1'171	0	
43	1'29	24'0	224	1'165	'005	1'195	0	Pressure-plate and cover added
44	1'22	22'5	228	1'112	'005	1'222	58	

TABLE II.—SUMMARY OF THE LOG.

Distribution of Friction.

6" X 12" Straight Line Engine.

Symbol.	Number.	Friction H. P.	Average F. H. P.	Parts of the Engine producing Friction.
A	34 35	0·873 0·825	0·849	Main journals.
B	32 33	0·922 0·966	0·944	Eccentric-strap and main journals.
C	36	0·972	0·972	Crank pin and main journals.
D	30 41 43 45	1·122 1·195 1·195 1·149	1·165	Cross-head and pin, crank-pin, eccentric and main journals.
E	40 42 23 24 25 26 27 28 31	1·758 1·867 1·925 1·844 1·728 1·752 1·868 1·690 1·732	1·796	Plain slide-valve, cross-head and pin, crank-pin, eccentric and main journals, with steam on.
F	43 6	1·195 1·189	1·192	Condition D, with balanced valve and pressure-plate added.
G	7 44	1·200 1·222	1·211	Condition F, with steam pressure.
H	1 2 3	1·710 1·822 1·822	1·785	Engine complete with balanced valve. No steam pressure but engine hot.
I	4 5	1·122 1·159	1·140	Condition D, with balanced valve added but pressure-plate off.

TABLE III.—COMPUTATION.

Distribution of Friction.

6" X 12" Straight Line Engine

COMBINATION OF CONDITIONS.		Result H. P.	Individual Part to which Friction is Due
Algebraic Work.	Arithmetical Work.		
A	·849	0·849	Main journals.
B — A	·944 — ·849	0·095	Eccentric-strap.
C — A	·972 — ·849	0·123	Crank-pin.
D — C [B — A]	1·165 — ·072 — ·095	0·048	Cross-head and pin.
E — D	1·769 — 1·095	0·631	Slide-valve, steam on.
G — D	1·211 — 1·165	0·046	Balanced valve, steam on.
H — F	1·785 — 1·192	0·593	Piston and rod

* Symbol of condition in column of algebraic work explained in previous table. Diameter of main journals, 3 inches, weight in main journals, 1,500 pounds.

TABLE IV.—PERCENTAGE OF TOTAL FRICTION AND OF RATED POWER.

6" × 12" Straight Line Engine, 20 H. P.

PARTS OF ENGINE.	ENGINE WITH SLIDE VALVE.			ENGINE WITH BALANCED VALVE.		
	Friction H. P.	Per Cent. of Total Friction.	Per Cent. of Rated Power.	Friction H. P.	Per Cent. of Total Friction.	Per Cent. of Rated Power.
Main journals, ...	0·849	35·4	4·2	·849	47·1	4·2
Eccentric-strap, ...	0·095	4·0	0·5	·095	5·3	0·5
Crank-pin, ...	0·123	5·1	0·6	·123	6·8	0·6
Cross-head and Wrist-pin, . .	0·098	4·1	0·5	·098	5·4	0·5
Valve (steam on), ...	0·631	26·4	3·2	·046	2·5	0·2
Piston and Rod, ...	0·593	25·0	3·0	·593	32·9	3·0
TOTAL, ...	2·389	100·0	12·0	1·804	100·0	9·0

LANSING ENGINE TRIALS.

Distribution of Friction, 12" × 18" Automatic Engine.—The remaining tests to be described were made at Lansing, Mich., and on the engines built by the Lansing Iron and Engine Works of that place.

The first engine tested was a new 12 × 18-inch automatic engine. A series of trials to determine change of friction with change of load was first made, which gave us the average friction, 8·91 horse-power, whether loaded or light. Considerable difficulty was experienced in attaching the dynamometer, and it is found impossible to obtain the friction on each distinct part of the engine. For this trial the springs of the dynamometer were flexed in the opposite direction from that adopted when it was calibrated; the results were taken as proportional, and the total made to agree with the previous trial. The highest speed attained was sixty-eight to seventy revolutions; the normal engine speed was in the previous trial 190 revolutions. The friction horse-power in the last column was obtained by multiplying by the proper ratio. In any event the percentage would not change.

Table V exhibits the distribution of resistances obtained in this case.

TABLE V.—DISTRIBUTION OF FRICTION LOG OF DYNAMOMETER TRIAL. LANSING IRON WORKS,
12" x 18" AUTOMATIC.

Rated 100 H. P.

CONDITION OF ENGINE.	Symbol.	Mean Ordinate.	Reading from Calibration Pounds.	Tension on Engine Belt, Pounds.	Speed of Engine in Revs. per Min.	H. P.	H. P. for 100 Revs. per Min.
Engine in working condition and hot, . . .	A	11.3	45	76.5	68	2.96	8.88
Piston, cross-head and connecting-rod dropped, ...	B	6.7	25	42.5	68	1.51	4.53
Valve and eccentric also dropped, . . .	C	5.6	19.75	33.5	73	1.40	3.79

COMBINATION OF RESULTS.

PARTS OF ENGINE.	Algebraic Work.	Arithmetical Work.	Frictional H. P.	Per Cent. of Total Friction.	Per Cent. of Power of Engine.
Main journals, ...	C	3.70	3.70	41.6	3.7
Valve and valve gear, including eccentric, ...	B — C	4.53 — 3.70	.83	9.3	0.83
Piston, cross-head, crank and wrist-pins, ...	A — B	8.88 — 4.53	4.35	49.1	4.35
TOTAL, ...			8.88	100.0	8.88

The letters used under head of algebraic work stand for conditions shown in the other table.

Distribution of Friction, 7" x 10" Engine—Locomotive Valve-Gear.—The test was conducted in the same manner as the original Sibley College test, except that the power was supplied by a similar engine, and the dynamometer was located between the two. The engine was a traction engine used in thrashing grain; it had a common slide-valve link and two eccentrics. It had been previously tested to find variation of friction with change of load. During the test the engine was taken to pieces in a thorough manner, as originally planned, and the results are in each case satisfactory. In the attempt to run with the connecting-rod disconnected from the cross-head, a machinist held the free end of the rod. A speed of 206 revolutions, however, caused him to exert some force, so that this result is unreliable, as the test shows the same friction as with the main journals alone. The friction on the main journals was measured with the usual fly-wheel, which weighed 320 pounds, and with one that weighed seventy pounds, to note variation in journal friction.

Table VI shows the method of variation of friction resistances in this case, as the engine was gradually dismantled ; and Table VII exhibits its distribution among the several elements of the machine.

TABLE VI.—DISTRIBUTION OF FRICTION.

Traction Engine—Locomotive Type. 7×10 . Lansing Iron Works.

CONDITION OF ENGINE.	Symbol of Condition.	Revolutions of Engine.	Mean Ordinate.	Tension on Dynamometer Belt in Pounds.	Friction H. P. at given Speed.	Friction H. P. 200 Revolutions.
Complete, hot, cocks open, ...	A	196	5'35	19'50	1'47	1'50
Complete, hot, back head off, ...	B	202	5'68	20'25	1'58	1'56
Piston and rod out, ...	C	202	4'36	14'75	1'14	1'13
Rod in, spider on, but piston-rings out, ...	D	200	5'14	18'00	1'40	1'40
Condition C, with 40 pounds steam on valve, ...	E	198	5'4	19'50	1'49	1'51
Valve and valve-rod off, ...	F	190	4'3	14'25	1'05	1'10
Remainder of valve-gear off, ...	G	203	3'6	12'00	0'94	0'93
Condition G, with governor off, ...	H	203	3'65	12'25	0'96	0'94
Cross-head and pin off (connecting-rod held by attendant), ...	I	206	3'1	9'00	0'71	0'69
Main journals, standard fly-wheel, weight } 320 pounds, ...	J {	200	3'0	8'75	0'67	0'67
Main journals, small fly-wheel, weight 70 lbs, ...	K	190	3'1	9'00	0'66	0'69
		262	2'3	5'75	0'57	0'44

TABLE VII.—DISTRIBUTION OF FRICTION.

 7×10 Engine.

Combination of Results.—Rated 20 H. P.

PARTS OF ENGINE CAUSING FRICTION.	COMBINATION.		Horse-Fractional Power.	Per Cent. of Total Friction.	Per Cent. of Rated Power of Engine.
	Algebraic Work.	Arithmetical Result.			
Main-journals, ...	$\frac{J}{2}$	0'68	0'680	35'2	3'4
Crank-pin, wrist-pin, and cross head, ...	$\frac{H + G}{2} - J$	$\frac{.94 + .93}{2} - .68$	0'255	13'1	1'3
Eccentrics and links, ...	$F - \frac{G + H}{2}$	0'165	0'165	8'2	0'82
Slide-valve and rod, no lead, ...	$\frac{C - F}{2}$	1'13 - 1'10	0'030	1'5	0'01
Effect of 40 pounds of steam, ...	$E - C$	1'51 - 1'13	0'380	19'5	0'19
Piston and piston-rod, ...	$D - C$	1'40 - 1'13	0'270	16'0	0'135
Piston-rings, ...	$\frac{A + B}{2} - D$	0'130	0'130	6'5	0'065
TOTAL, ...	...	...	1'910	100'0	9'52

NOTE.—In the column headed algebraic work, the letters refer to conditions as denoted in preceding table.

DISTRIBUTION OF FRICTION.

Engine, Condenser and Air-Pump.—Diameter twenty-one inches, stroke twenty inches. This engine, 21 x 20 inches, in connection with an engine 12 x 10 inches, made a compound condensing engine which drove the Thomson-Houston dynamos, used for the electric lighting of the city of Lansing. A complete test for friction, with change of load had previously been made of these engines, separately and combined. This engine being larger than could be driven by power transmitted through the dynamometer, the plan was adopted of utilizing the connecting-shaft between the high- and low-pressure engine, and of measuring the power necessary by indicator-cards on the high-pressure engine. Metallic paper, and a fine brass point was used instead of the usual paper and pencil employed in taking indicator-cards. Two dynamos were allowed to run light during the whole of this test, being driven by the high-pressure engine: this friction being eliminated in the final result.

The method adopted was to take indicator-cards of the high-pressure engine, and the load to be carried throughout the test; then to add successively the main journals in the engine to be tested, the condenser and air-pump, the connecting-rod and cross-heads, the valve and valve-rod, and finally the piston and piston-rod.

The plan was in great part successful, but could not be entirely carried out.*

Table VIII shows the distribution of the friction in this series of trials.

There were several conditions during this test that were not uniform throughout; nor were they normal. For instance, in cases *C*, *D* and *E* cards 7 to 15, the valve or piston of the engine or both was in motion, and it was

* A serious accident was barely escaped after the air-pump had been attached and while the connecting-rod was detached from the crank-pin. The vacuum caused by the working of the air-pump, drew the connecting-rod toward the rapidly revolving crank; the meeting of the two was heralded by a sudden and violent pounding. The rapidity of the motion prevented any serious damage, until the connecting-rod could be safely put out of the way.

impossible to lubricate the valve, although the piston was lubricated without difficulty. The results in both cases, *C* and *D*, can be considered as relative only, not absolute. Again, in case *E*, it was found impossible to prevent the

TABLE VIII.—DISTRIBUTION OF FRICTION.

Condensing Engine.

21" × 20" built by Lansing Iron and Engine Works.

CONDITION OF ENGINE.	Symbol of Condition.	No. of C. rls.	Revolutions per Minute.	HEAD INDICATOR.		CRANK INDICATOR.		Total Friction. H. P.	Average Friction. H. P.
				M. E. P.	F. H. P.	M. E. P.	F. H. P.		
High-pressure engine and fixed load.	A	1	207	4.5	14.36	5.0	15.52	29.88	28.9
	A	2	207	4.5	14.36	4.0	12.42	26.78	
	A	3	207	4.75	15.16	4.75	14.74	29.90	
Main bearings of 20 × 24 engine coupled on.	B	4	205	4.5	14.23	6.25	19.21	33.44	35.2
	B	5	205	4.5	14.23	5.75	17.67	31.99	
	B	6	205	4.75	15.02	5.75	16.13	31.15	
Valve and valve-rods connected to eccentrics.	C	7	204	4.75	18.56	7.5	28.50	47.06	42.5
	C	8	202	5.0	19.35	5.5	19.79	39.50	
	C	9	200	5.0	19.16	6.0	22.36	41.52	
Air-pump and condenser added.	D	10	198	5.0	19.27	8.5	31.35	50.62	48.6
	D	11	200	5.3	20.51	7.3	27.47	47.98	
	D	12	192	5.0	22.07	7.0	25.04	47.11	
Connecting-rod with cross-head and piston added. Air-pump gauge with pressure as shown subsequently.	E	13	200	13.5	52.73	14.15	54.96	107.69	113.88
	E	14	172	17.5	57.68	18.5	59.28	116.96	
	E	15	172	18.0	57.68	18.0	59.32	117.00	
Average work shown by vacuum-gauge.	F	...	...	...	...	...	...	...	63.80

action of the air-pump on the piston: the work done was, however, shown by the vacuum-gauge, and was equivalent, respectively, to a pressure of 9.82, 10.3 and 10.3 pounds, in cards 13, 14 and 15, or a work equivalent to 69.26, 61.12 and 61.12, with an average of 63.8 horse-power, over and above that due to moving the engine. The average of a large number of previous trials gave 7.13 horse-power as the total friction of this engine together with air-pump and condenser; and this fact must be noted in considering cases *C* and *D*.

Combining these various observations, we get the following results: Friction on main journals equals

$$B - A = 3.3 \text{ H. P.}$$

Engine complete, air-pump at work, case *E*, gives 113.88 horse-power; without piston, air-pump and unlubricated valves as before, gives us case *D*, 48.60 horse-power. The difference, 65.28 horse-power, includes work of air-pump and friction of piston and rod. The work of air-pump is 63.8 horse-power, leaving for friction of piston and rod 1.48 horse-power.

The difference between the total friction, and that on the parts, already found, is the sum of the friction for cases *C* and *D*, which must be divided in the proportion indicated by the observations. Table IX is a summary of the deductions from this set of trials of a condensing engine.

TABLE IX.—DISTRIBUTION OF FRICTION.

Condensing Engine, 21" × 20".

Summary of Results.

PARTS OF ENGINE CONSIDERED.	Conditions Combined Algebraically.	Friction, Horse-Power.	Per Cent. of total friction.
Main journals, ...	$B - A$	3.3	4.0
Piston and rod, cross-head and pins, . .	$E - (D + F)$	1.48	2.1
Valve-rod and eccentric, ...	Determined as explained	1.47	2.1
Air-pump and condenser, ...	" " "	0.88	1.2
TOTAL, ...	. . .	7.13	10

COEFFICIENT OF FRICTION.

The coefficient of friction can be deduced with certainty only for the main journals of the engine: since there is a variation in pressure of piston-rings, stuffing-boxes, and in angularity of the connecting-rod, which is, at least to a great extent, unknown.

If we call f the coefficient of friction, p the pressure on the bearings in pounds for engines light, and p plus mean pressure on piston for engines loaded, c the circumference of the bearings in feet, n the number of revolutions per

minute, $f p c n$ will thus equal the "lost work" of friction; which has been determined in the previous experiments,

TABLE X.—COEFFICIENT OF FRICTION FOR THE MAIN BEARINGS OF STEAM ENGINES.

ENGINE.	F. H. P. due to Main Journals.	Weight on Journals in Pounds.	Diameter of Journal in Inches.	Coefficient of Friction, Engine Light.	Coefficient of Friction, Engine Loaded.	Revolutions of Journal per Minute.
6" x 12" Straight line, ...	0.85	1,500	3	.10	.06	230
*12" x 18" Automatic (L. I. W.), ...	3.70	2,600	5	.19	.05	190
7" x 10" Traction (L. I. W.), ...	0.68	500	2¾	.31	.08	200
21" x 20" Condensing (L. I. W.), ...	3.30	4,000	5½	.09	.09	206

* The 12" x 18" automatic engine was new, and gave, throughout, an excessive amount of friction as compared with the older engines of the same class and make.

TABLE XI.—DISTRIBUTION OF FRICTION.

Summary of Results.

PARTS OF ENGINE.	PERCENTAGES OF TOTAL FRICTION.				
	Straight Line 6" x 12" Balanced Valve.	Straight Line 6" x 12" Unbalanced Valve.	7" x 10" Lancing Iron Works—Traction Locomotive Valve-Gear.	12" x 18" Lancing Iron Works—Automatic Balanced Valve.	21" x 20" Lancing Iron Works—Condensing Balanced Valve.
Main bearings, ...	47.0	35.4	35.0	41.6	46.0
Piston and rod, ...	32.9	25.0	21.0		
Crank-pin, ...	6.8	5.1		49.1	21.8
Cross-head and wrist-pin, ...	5.4	4.1	13.0		
Valve and rod, ...	2.5	26.4	22.0	9.3	21.0
Eccentric-strap, ...	5.3	4.0			
Link and eccentric, ...	...	...	9.01	...	...
Air-pump, ...	...	...	...	...	12.0
TOTAL, ...	100.0	100.0	100.0	100.0	100.0

and is expressed as horse-power; this is indicated to foot-pounds by multiplying by 33,000.

Hence,

$$f c p n = 33,000 \text{ H. P.}$$

$$f = \frac{33,000 \text{ H. P.}}{p. c. n.}$$

Table X shows the value of this coefficient for the several engines tested, and Table XI is a summary of *all* results.

CONCLUSIONS AND DEDUCTIONS.

In each case the engine to be experimented with was first examined, by the process which has been so fully described in the preceding papers on this subject, to determine whether its friction under varying loads was actually constant, as in the engines previously tested. This was found to be practically the case in every instance, and even the compound engine, contrary to the expectation of the writer, exhibited substantially the same internal friction at all loads up to its full rated power, and with no load at all. The minimum friction was 13.5 horse-power, the maximum 17.5, varying irregularly, with the character of the lubrication, probably, and giving the higher or the lower figure indifferently whatever the work done, and however the power might be distributed between the two cylinders. As this engine was non-condensing, the problem still remains to be solved with respect to condensing engines, unless, indeed, the few experiments thus far reported may be taken, as is very probably the fact, as indicating the truth of the general principle of constancy of internal friction for all engines, whether condensing or non-condensing.

These engines were also all tested to determine whether the previously reported increase of internal friction with speed were here to be accepted as correct. It was found that the several engines differed somewhat in this respect, but that the variation was in all cases slight, and in some instances insensible or even reversed, the friction decreasing in one case, observably, with increasing speed. It was sufficiently evident, for all the engines here considered, that this variation was so unimportant as to be negligible. The

figures given in the several tables which have been presented in the preceding pages are therefore to be accepted as not only correct and reliable, but also as not likely to be affected by construction or method of operation of engine to such an extent as to be inapplicable to steam engines generally. The writer, in the light of existing knowledge, would assume that it is the rule, with all the usual forms of engine, and under all common conditions of operation, that the internal friction of the machine is practically invariable with variation of useful work, and that it is very nearly independent of the speed of rotation and of piston, varying slightly, as a general rule, in the direction of increase with increase of speed. This latter principle leads to the conclusion that the friction coefficient of the rubbing surfaces decreases with the load on the engine and with increase of pressure on them, a result confirmed by numberless experiments of the writer and others, independently. With good lubrication, the coefficient of friction rapidly decreases with intensifying pressures, and to such an extent as to make the actual resistance to movement very nearly constant. It is now possible to study the reported data intelligently, and to deduce useful and reliable conclusions relative to the effect of these new facts upon the theory and upon the principles of designing and constructing as well as operating steam machinery.

The last table presented, summarizing the work of the whole research, gives in most readable and intelligible form the data and the laws which it has revealed. The most important item of friction waste, in every instance, is that of lost energy at the main bearings. In every case it amounts to one-third or one-half of all the friction resistance of the engine, the higher figures being given by the condensing, the lower by the non-condensing engines, except that the first experiment, with the straight line engine, gives as high a figure as the condensing engines, a fact due, however, rather to the exceptionally low total than to exceptionally high friction on the main shaft. The second highest item is, in all cases apparently, the friction of piston and rod, the rubbing of rings and the friction of the rod pack-

ing. This is a very irregular item, as would naturally have been anticipated, and amounts to from a minimum of twenty per cent. to some higher but undetermined quantity. The third item, in order of importance, is the friction of valve, in the case of the engines having unbalanced valves. This is seen to be hardly a less serious amount than the frictions of shaft and of piston. But it is further seen, at once, that this is an item which may be reduced to a very small amount by good design, as is evidenced by the fact that, in the straight line engine, it has been brought down from twenty-six to 2·5 per cent. by skilful balancing. Ninety per cent., therefore, of the friction of the unbalanced valve is avoidable or remediable. The importance of this fact is readily perceived when it is considered that not only is it a serious direction of lost work and wasted power and fuel, but that the ease of working of the valve is a matter of supreme importance to the effective operation of the governing mechanism in this class of engines. No automatic engine can govern satisfactorily when the valve is unbalanced, and is certain to throw much load on the governor. The frictions of crank-pin, of cross-head, and of eccentrics, are the minor items of this account; they are comparatively unimportant.

Studying these facts with a view to further improvement of the steam engine, certain inferences are at once obvious. The improvement of the steam engine has to-day reached a point beyond which, in its thermodynamic relations, but little advance can be anticipated. Under usual conditions of operation of our very best engines, they are so near the efficiency of the ideal engine, working under precisely similar conditions, that the range of possible gain left to us is too small to permit us to look in that direction for rapid or important changes in further increase of efficiency and economy. Where the ideal engine would consume ten pounds of steam per horse-power per hour, we have actually reached as little as fourteen, if the latest and best reports of the best of modern engines may be accepted as substantially correct; and even this thirty per cent. margin is reduced by practical conditions restricting expansion. If it

were to be asserted that we may hope to bring the consumption of steam in good engines of the best type down to as low as twelve pounds per hour per horse-power, it is probable that the most experienced and best informed engineers would think it a somewhat rash statement; but, in the opinion of the writer, that is what the tendency and rate of recent improvements would seem to promise for the immediate future, assuming that no very great increase in pressures and temperatures of steam may be expected. Practically, also, it is now known that the highest duty is not the most desirable, nor, on the whole, the most advantageous condition of operation of the engine, and we are restricted to lower duties and reduced efficiencies whenever we consider financial relations. It is, nevertheless, the fact, that the conditions of improvement are those which also give higher ratios of expansion for the best point of cut-off and most advantageous ratios of expansion. The duty to seek further means of improvement and higher efficiency becomes all the more imperative when we study the practical conditions under which our engines must be employed. Having, however, as just remarked, so nearly reached the limit of possible gain on the thermodynamic side, it becomes advisable to seek the more carefully for opportunities of improvement in other directions. We have, in the work outlined in this paper, both the directions shown us and the specific method of procedure suggested.

The real, final efficiency of the steam engine, or of any heat engine, as has been somewhat fully shown in earlier papers by the writer,* and later by others, is composed of the resultant of several distinct efficiencies, as the thermodynamic efficiency, the efficiency of the engine as a heat preserver and user, the efficiency as a machine, and the efficiency of a whole considered from a commercial standpoint. Of these several efficiencies, we have in this investigation the means of studying the efficiency of the machine as a division of the whole within which to seek the best

* "On the Several Efficiencies of the Steam Engine." *Trans. Am. Soc. M. E.*, Vol. viii, p. 86.

means of securing a gain of total efficiency. The real and final efficiency is certain to be increased if we can effect an improvement at this point, whatever the extraneous conditions of operation. Finding little chance of gain thermodynamically, it becomes our duty to ascertain what are the probabilities of securing progress elsewhere. It is at once seen that the difference here between the real and the ideal engine is greater than in the domain of thermodynamics, the best cases being in both instances taken. Those engines which are most nearly perfect thermodynamically, are undoubtedly often least perfect, or at least of the least perfect types, when the efficiency of the engine as a machine is studied. Few of them have less than a total of twenty per cent. friction; while they are sometimes probably nearer the ultimate limit of improvement, practically, as converters of heat into work. We are now, for the first time in the history of the theory of the steam engine, in a position to say just where the losses of the machine are in detail, how we are to endeavor to reduce them, in what degree we may hope for such gain, and where it is to be found if effected at all.

The first and most remarkable fact to be noted is the extraordinary amount, absolutely and relatively, of the friction of the crank-shaft. This amounts to nearly one-half of the whole waste, and to from five to ten per cent. of the whole power of the engine, in the cases here examined. It is remarkable not only for its amount, but also because of the fact that we had begun to believe that, under similar conditions of pressure, speed of rubbing, and of lubrication, it was perfectly practicable to bring down the coefficient to less than one per cent. and perhaps to as little as one-tenth of one per cent. Here, however, we find, on examination of Table X, that this coefficient rises, in the unloaded engine, to about 0.30 as a maximum, and, as a minimum, to at least 0.09; while it only falls to 0.04 in the best case, with the increase of pressure on the bearings due to full load and power. This is the more astonishing when it is considered that, on the axle of the car-wheel, it has been found often that the friction is a fraction of one per cent. and often as low as

one-tenth per cent. Here is evidently the first place in which to seek further improvement. If this item can be brought down as low as in car-axle journals, the efficiency of the engine as a machine will be increased by about five per cent. in the very best cases, and by ten per cent. in ordinary engines. How this is to be done can be best ascertained when it is found just what are the causes of this extraordinary and previously unsuspected loss. The only conditions apparent tending to exaggerate this waste are the continuous rotation in one direction and the unintermitted pressure of the journal in its bearing. It would appear probable that it is a case of commonly imperfect lubrication. Could the oil-bath system in method and in results be secured here, it would seem probable that the friction might be enormously reduced. It would even in many cases, if not in all, pay well to have a thoroughly reliable system of lubrication by means of a forcing pump that should insure the support of the journal upon a cushion of lubricant, thus making its action analogous to that of the "*palier glissant*" of Giffard and the "water bearing" of Shaw and of others.

The second and most obvious conclusion is that the valve should be balanced and so connected as to cause the least possible waste by friction through its motion or that of its moving connections. There is evidently no probable line of improvement so certain to yield a large and profitable result as this. The balancing of the valve has been accomplished, and frequently, during many years past, and so successfully that there is no excuse for neglecting this point in even the cheapest classes of engines. No engine can be considered as belonging to the best class which is not either provided with a balanced valve or which has not a system of valve-gear as with some of the "drop cut-off" engines, in which the loss in this direction is rendered insignificant. Here lies an opportunity to raise the efficiency of mechanism of ordinary engines at least five per cent., and of the best of engines with unbalanced valves two or three per cent. It is evidently better, in many cases, to have a valve which is balanced, though slightly leaky at times, than to use an unbalanced valve, though absolutely tight at

all times. The simple fact, here revealed, that nine-tenths of this friction may be avoided is very important.

The third item in order of importance is the friction of piston and its rod. This is as great as that just referred to, and is vastly more variable with the class of engine, and probably in the same engine with differences in handling, and especially in setting up packing and springs, where they exist. The writer has often known the power of an engine to be sensibly affected by the carelessness or inexperience of the attendant, who had screwed up his packing in the rod stuffing-box too tightly, and has, on more than one occasion, had a similar experience where the rings were set out too hard. The metallic packings and the unpacked pistons and rods now coming slowly into use will unquestionably do much to remedy this defect of the average engine. Meantime, with the older design, it is perfectly possible to keep piston and stuffing-box tight without wasting much power, or by slowing down the engine by conversion of heat into work at points where the operation is likely to produce serious harm as well as waste. Rings are much oftener too tight than too loose, and a stuffing-box should only be set up when the engine is running, and then only with fresh packing and not more than is sufficient to check any visible leakage. New packing in a well-made box never needs much compression and when it becomes necessary to screw it down hard, it is time to replace it by new. Any packing that compels severe compression when new should be promptly condemned.

The remaining items are of minor importance as bearing upon the efficiency of the machine, and they are all obviously easily taken care of by a good designer and a good engineer in charge. Here, if anywhere, it is the fact that freedom of lubrication is the essential consideration, and the more nearly absolutely flooded the parts can be, and the more absolutely certain lubrication can be made, the better, and irrespective, also, to a great extent, of the cost of the lubricant. Any lubricant freely used can be filtered and cleansed in such manner and so effectively, that its more or less free supply to the bearing is a matter of no

consequence as a matter of first cost, while the cost of wasted power and fuel, and of repairs due to excessive friction and wear, will usually enormously exceed any apparent gain in that direction. This latter consideration has been very fully treated by the author elsewhere,* and is probably also too familiar to engineers of experience to make it advisable to extend the limits of this paper so as to include more of detail in this and other matters. The importance of the work of which this is the history is sufficient, however, probably, to justify the length to which the paper has already extended.

By reducing the several items of waste and loss above enumerated to their minimum amounts, in the various ways pointed out, and by other less obvious expedients, it is evident that the efficiency of the machine may be so far advanced, in the case of the ordinary engine, as to give us the power of applying from five to ten per cent. of the total indicated power of the engine to useful, instead of to wasteful purposes, and thus to effect a gain of no small amount by improving both sides of the account.

Messrs. Carpenter and Preston have done other work of value, to which it may be possible to give attention later, and Prof. Carpenter is independently pursuing the study of the internal friction of engines. It is hoped that we may, in time, secure a very large body of valuable data, and especially that we may, after a time, be able to indicate the laws of its distribution with some accuracy for all types and styles of engine in common use.

* *Friction and Lost Work in Machinery and Mill-Work*. J. Wiley & Sons: New York. 1885.

ELECTRIC WELDING.

[*Abstract of remarks made by Prof. Elihu Thomson, on showing his electric welding apparatus in operation, at the stated meeting of the FRANKLIN INSTITUTE, held September 19, 1888.*]

JOS. M. WILSON, President, in the Chair.

Prof. THOMSON spoke substantially as follows :

About a year and a half ago I gave a description of the newly-developed art of electric welding, calling attention to the principles underlying its practice and the results accomplished in the welding of various metals and alloys.

On the present occasion, the purpose is to show the apparatus, or at least a few forms of it, in operation, and to describe the working and construction.

Quite a number of types of apparatus have been developed, some of which are before us, and others we have at our factory at Lynn, Mass.

What we call the indirect, or induction, type takes current of comparatively high potential from a dynamo giving alternating currents, or from any other suitable source, such as a lighting supply line, and converts, or induces, from it a current of very low potential and great volume for electric welding, soldering, brazing and forming of metals. One form of apparatus, which will be used for welding iron and copper wires, is here before you (*Fig. 1*).

The "direct" type generates the currents needed directly from belt power or mechanical energy, and consists of a specially organized dynamo provided with a set of welding clamps. In fact, the needs of electric welding have given rise to a number of special and somewhat curious types of dynamos, which might not otherwise ever have been invented or constructed. But one of these forms is here shown, a number of others having been designed and constructed, and others again are undergoing construction. *Fig. 2* is an example of a type of direct-welding dynamo,

similar to the one on the platform, belted to the INSTITUTE engine.

The storage battery, properly arranged, constitutes another type. It is charged from a line, or by a small dynamo kept running constantly by power. Since the welding or heavy-discharge currents are only needed at intervals, a comparatively small dynamo will usually suffice for the charging. We have used a suitable cell of storage battery quite successfully in electric welding. Even primary batteries may, if of sufficiently low internal resistance, be used for the work, but are comparatively expensive to run.

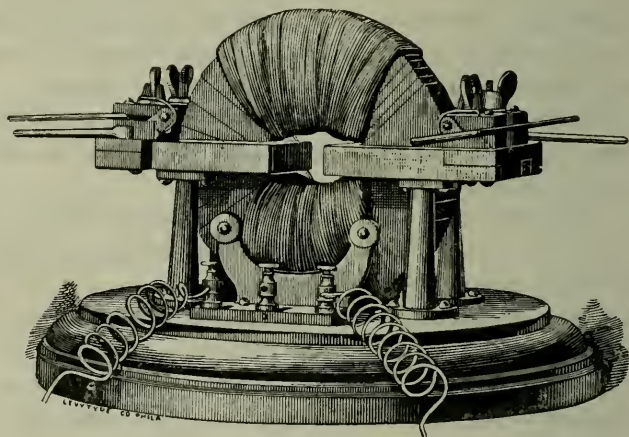


FIG. 1.

Variations in the proportion and details, especially of the clamping devices, are made to suit the nature and size of the work to be done, and the shape of the pieces to be handled.

It may be mentioned that for some purposes a combined engine and dynamo for welding may come into use, especially where the work is intermittent. Thus an apparatus in all respects like a steam fire engine, but with a dynamo generating the requisite currents and substituted for the pumps, would be useful where portability is requisite and comparatively heavy work is to be done in isolated localities. The fact that the work is intermittent permits the use of less

boiler capacity than would be the case were the plant to be under full load continuously.

(At this point a number of lantern slides were shown on the screen. They represented some of the various forms of apparatus which have been constructed, and their differences were pointed out.)

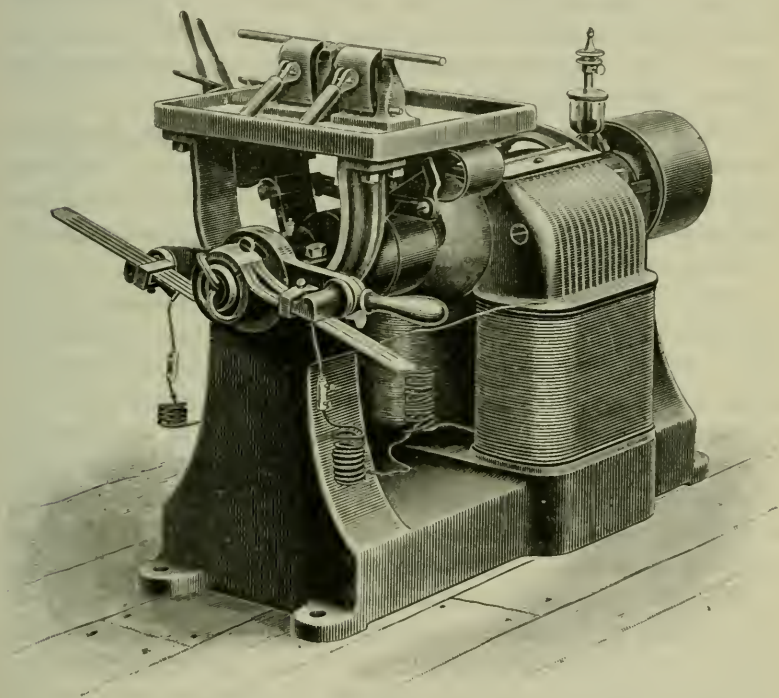


FIG. 2.

Prof. THOMSON continued :

I call attention to the numerous examples of work done as exhibited by the specimens which are found on the two sample boards before you, and upon the table. Here is a unique specimen, a shaft with two collars, formed without any welding at all, by simply pressing it endwise by the clamps with the current put on.

Here, again, is a very curious piece, which I am sure could not be produced at all without such apparatus as is

shown here. It demonstrates the rapidity with which work can be done, and the localization of the heating effects.

The specimen referred to is one in which a bar has been put through a hole in a flat piece of wood, and burrs raised on the bar at both sides of the wood, so that the wood is held between the two expansions in the bar, and almost pinched between them. The operation was so quickly done that the heat had not time to char the wood and enlarge the hole ; or, if I may be permitted to say it, the wood had not time to find out that it should burn.

Among the specimens here shown are rings, cast-iron pieces, various tools constructed by use of electric welding, chains and links, etc. The various metallic alloys, as brass, German-silver, are seen, in addition to heterogeneous welds or welds of different metals one to the other.

Many persons are puzzled to know how a ring can be welded at all by the current, especially such small and thick rings as are here shown, but there is no mystery about it. The current goes by the short path in greatest amount, and so welds the ring. This is particularly true of alternating currents of rather rapid rate, and, in fact, we have organized devices which absolutely prevent more than a small fraction of the current going around the ring. To do this we have only to establish conditions such that a current going around the ring has to produce magnetism in a closed iron core, while that which does the welding is comparatively free from such necessity. In such case, self-induction, and resistance are both acting together to prevent flow around the ring, instead of across the joint to be made.

Tests of tensile strength of electric welds are eminently satisfactory, and the occasion may sometime come when I can present the results, or consider for you electric welding from the standpoint of its perfection as a welding process. Its utility is, however, already established. It does very many things which no other process can do or has done.

Here is a sample of lead pipe welded without obstruction of its interior, and even without expansion outside. At a short distance away, the pipe cannot be distinguished from a plain piece, and its exterior has been left just as it came out of the welding clamps.

Here again, is a finished axe, with the steel cutting edge welded to the body by electrical means, the welding being the last operation done before final grinding for finish.

Here is a steel rake made by electricity, and several specimens illustrating the making of carpenter's squares by electric welding.

(Prof. THOMSON then explained the apparatus, which had been brought for inspection of the INSTITUTE, and showed practically the operation of electric welding.

He used both the induction coil type (*Fig. 1*), and the direct types (*Fig. 2*). Some of the apparatus was remarkable for its small size in relation to the size of the pieces upon which it would successfully operate. The devices for holding the pieces in place, putting on the current and giving the pressure to the pieces were shown to be very simple and easily operated.

He also exhibited some automatic apparatus, in which the pressure given is automatic, and the current stops when the weld is completed, thus enabling the operation to be indefinitely repeated in the same way without involving skill on the part of the operator.

At the close of Prof. THOMSON's remarks, a vote of thanks was tendered to the speaker for his extremely interesting presentation of the subject.)

MEMOIR OF THOMAS USTICK WALTER, LL.D.

BY GEORGE C. MASON, JR.

THOMAS USTICK WALTER, LL.D., second President of the American Institute of Architects, was born in the city of Philadelphia, September 4, 1804, and died in the same city, October 30, 1887, being, at the time of his decease, the oldest practising architect in the United States. He was a son of Joseph S. and Deborah Walter, and was named after the Rev. Thomas Ustick, a well-known divine during the early years of the present century.

In boyhood Dr. WALTER displayed a predilection for mathematics. His education was liberal, but not scholastic. In 1819, being then fifteen years of age, he entered the office of William Strickland, the architect of the Mint and Custom-House. From his own writings it is learned that he remained with Strickland until he had acquired the art of linear drawing and a general knowledge of the profession of architecture, after which he resumed his general studies and subsequently went through an elaborate course of mathematics. For seven years he devoted himself to the study of physical sciences, to the cultivation of the arts of drawing and painting, and to the attainment of practical knowledge of the several branches of mechanical construction; at the same time he studied landscape painting in water-colors with Mason, a celebrated teacher of that art. In 1828, he again entered Strickland's office, devoting himself exclusively to architectural study, the practice of which he commenced in 1830. In 1831 he designed the "Philadelphia County Prison." This was his first important work; his plans being adopted and he formally appointed architect October 14, 1831.

At a meeting of the FRANKLIN INSTITUTE, held September 10, 1829, he was elected to membership, being proposed by Mr. S. V. Merrick. On January 14, 1830, he was elected one of the Board of Managers. Dr. WALTER'S

interest in the FRANKLIN INSTITUTE was active from the first and he entered heartily into its counsels and discussions. Even at this early date, when the public taste for correct architecture was wholly undeveloped, he worked and argued for the advancement of his art. This enthusiasm bore fruit. July 16, 1835, it was voted, "That a course of lectures on architecture delivered annually before this Society is indispensable as well to accomplish the ends as to promote the prosperity of the FRANKLIN INSTITUTE, and that it is hereby warmly recommended to the Board of Managers to secure the delivery of such a course next winter."

The times were not altogether propitious for the establishment of a regular professorship; but on January 3, 1836, Dr. WALTER was requested to deliver "voluntary lectures." These lectures he continued to give from time to time and on April 1, 1839, he was again requested to "lecture on architecture during the following winter," and thenceforth his name appears on the JOURNAL as "Professor of Architecture."

Dr. WALTER, during these early years of his practice, and his connection with the FRANKLIN INSTITUTE, frequently contributed to its JOURNAL. He fully appreciated the dignity of his art, and from the first his pen and his public utterances were all to one end—its elevation and the cultivation of high aspirations among its practitioners. Thus, in 1841, he writes: "If architects would oftener aim to *think*, as the Greeks thought, than to *do*, as the Greeks did, our columnar architecture would possess a higher degree of originality, and its character and expression would gradually become conformed to the local circumstances of the country and the republican spirit of its institutions."

Among the articles, which, from time to time, he contributed to the JOURNAL during these years, may be enumerated the following titles:

"Architecture in the Middle Ages."

"Formation of an Artificial Spectrum."

General articles under the head "Architecture."

"Orders of Architecture."

Elaborate reports and descriptions of the design and construction of the County Prison and Girard College, then in course of erection, besides numerous other articles.

On January 21, 1846, Dr. WALTER was elected Chairman of the Board of Managers, and held the office for one year.

Dr. WALTER'S professional practice rapidly increased. His design for "Girard College for Orphans" was adopted by Councils in 1833, and the corner-stone laid on July 4th, of that year. This work was completed in 1847. He was then elected one of the Board of Directors of the College, serving for three years.

In 1838, the Building Committee of the College sent Dr. WALTER to Europe for the purpose of "examining the practical workings of the various devices and appointments for health, convenience and comfort, in the principal seats of learning in Great Britain, and on the Continent, with a view to derive such information on these subjects as would be likely to prove useful in fitting up and furnishing the building of the College."

We must now recall an event which may be said to have been the beginning of all architectural development and systematic and united methods of architectural practice in the United States, viz: the attempt, in 1836, to found an "American Institution of Architects."

At that time there were only about a half score of properly trained architects in the country. These gentlemen met in the city of New York, December 7, 1836. Dr. WALTER was one of the pioneers of the movement, and of the group of architects who met on that day, one alone remains—Alexander J. Davis, the architect of the "University of the City of New York." A draft of a constitution was formulated, and the meeting adjourned to meet in Philadelphia on the first Tuesday of May, 1837. The circular calling for this meeting, dated March 23, 1837, was signed by THOMAS U. WALTER, Secretary, and the meeting was held at the Pennsylvania Academy of the Fine Arts, in Philadelphia.

The "Institution" did not last. It embraced but a handful of members, and those too much scattered for mutual

sustenance and the strength necessary for a brotherhood. It struggled for awhile, flickered and went out.

In 1843, Dr. WALTER was invited by the government of Venezuela to visit La Guayra, with a view to the construction of a mole or breakwater. His designs and estimates were approved, and on the 12th of October, 1843, he entered into a contract for the erection of the work. On October 24, 1845, the breakwater was finished and accepted by the government. He then returned to Philadelphia and resumed his general practice.

In 1849, Madison University, New York, bestowed upon Dr. WALTER the honorary degree of Master of Arts.

Dr. WALTER'S position was now assured. He had designed and executed noble works, well and honestly constructed, and designed in the pure classical style of which he was the most strenuous advocate and enthusiastic student. Among his works of private practice may be enumerated St. George's Hall, the Preston Retreat and the Biddle and Cowperthwaite places on the Delaware River.

But all these creditable works, and the struggles of his early years, were but the training and leading up to, as it were, the one great work with which his name must ever be associated, the extension of the Capitol at Washington, D. C., together with the noble dome which surmounts and dignifies its mass.

On the 11th of June, 1851, Dr. WALTER was appointed architect of the Capitol extension in the following letter:

TO THOMAS U. WALTER, ESQ.:

SIR: You are hereby appointed architect to execute the plan adopted for the extension of the Capitol as authorized by the Act of Congress, approved 30th September, 1850, making appropriations for the civil and diplomatic expenses for the Government for the fiscal year ending 30th June, 1851; your compensation will be determined hereafter.

MILLARD FILLMORE.

Washington City, June 11, 1851.

The appointment was well merited. Of all American architects of that time, Dr. WALTER was the best fitted by study and innate love for the purest types of classic architecture to grasp successfully the problem of the Capitol extension, and to design the dome with which, later, he glori-

fied and crowned his work. The boldness of his composition evidences his skill as a designer and his confidence in himself. The vast wings forming the extension are of white marble, of great hardness and durability—they have taken upon with years a delicate pearly color, which, as it shows itself in the long colonnades, gives them an effect of purity and beauty. The crowning glory of this edifice is the dome. Much as we pride ourselves upon the advances made in architectural design, we have nothing to show more nobly simple and well studied than this, the grandest of Dr. WALTER's works. Such is the verdict of the architect and the critic. Fergusson, the historian of architecture, and often a severe censor, writes: "Taking it all in all, however, there are few buildings erected in modern times which possess to a greater extent than the Capitol at Washington appropriateness of purpose combined with the dignity necessary for the Senate house of a great nation. It has not the variety and richness of detail of our Parliament houses, but it is a far statelier building, and its faults are those of the age in which it was commenced, and which have tied the hands of subsequent architects, and prevented them from using the improvements that have since been introduced in the arts of design; but it wants but very little to enable it to attain to very high rank among the buildings of its class in other parts of the world."

The Hon. J. H. B. Latrobe, son of Benjamin H. Latrobe, the architect of the old Capitol at Washington, thus eulogized Dr. WALTER in an address before the American Institute of Architects in the city of Washington, November 16, 1881. Speaking of the extension of the Capitol Mr. Latrobe said: "I can scarcely speak in his presence as I would like to speak, could I find words to do justice to the last architect of the vast pile that now looks down upon the Federal City. The pupil of Strickland, as Strickland was the pupil of my father, it has been with me a pleasing fancy for more than a quarter of a century to believe that there was, in some faint way, a law of descent, applicable under the circumstances, which connected the architect who clothed Thornton's skeleton with sinew and muscle and beauty until the

whole creature became his own, with his brilliant, refined and accomplished successor, who, at the head of a profession, socially, to-day, without a superior, has absorbed all that has been done before in what is now the Capitol; who, making the magnificent dome, on whose iron sheets the hammer never ceased to ring during the war that threatened to make the whole structure worthless, has screened with it all the exterior littleness of a vitiated taste, and made even the incongruities of the Italian Renaissance subserve the purposes of genius."

Ill health compelled Dr. WALTER to resign from the service of the Government, June 1st, 1865, and he then returned to Philadelphia.

Among the important works that Dr. WALTER executed for the Government between 1851 and 1865 may be enumerated:

The extension of the Patent Office;

The repairs to the Congressional Library;

The extension of the Treasury Building;

The general Post-Office extension;

The Government Hospital for the Insane;

all at Washington; and the Marine Barracks, at Brooklyn, N. Y., and at Pensacola, Fla. In 1860 he delivered a course of lectures on Architecture at Columbian College, D. C., and he also delivered lectures on the same subject in Philadelphia and vicinity.

In 1853, the University of Lewisburg, Pa., conferred upon Dr. WALTER the degree of Doctor of Philosophy, and in 1857, Harvard University gave him the degree of Doctor of Laws. He also became a member of the American Philosophical Society.

Dr. WALTER was now well advanced in years and full of honors. After his return from Washington he engaged in but little private practice. When the erection of the new City Hall was commenced he became connected with Mr. John McArthur, Jr., its architect, and continued to assist him on that work until a short time before his death.

Of Dr. WALTER'S connection with the American Institute of Architects the profession may well be proud. The

original "Institution of Architects" had fallen to pieces for want of cohesion. The American Institute was founded in 1857, and on February 23d, of that year, Dr. WALTER was elected a Fellow. On the retirement of its first President, Richard Upjohn, in 1876, he was elected President, which office he filled continuously until his death. His words of counsel and the dignity of his character have done much to enhance the power and influence of the Institute. At his last election to the presidency, December 2d, 1886, he thus expressed his thanks to the Convention; the words are simple and touching and seemed to those who heard them prophetic of the great change to so soon come upon him:

"I return you my thanks, gentlemen, for your kindness, and for your forgiveness. You might have done better all the time; but I began with you almost at the beginning and have been in my place as often as it was possible; and have done the best I could; and I intended, when I came here, to decline a re-election; but my friends have been very kind, and have asked me to agree to it, if I were re-elected, and I have agreed to it for another year. After that, should I live so long, I will ask you to allow me to take a rest. As to the year before us I promise to do all I can for the promotion of the prosperity of our profession, and for the promotion of the interests of our Institute. Everywhere and at all times I am yours, asking you now to look over my imperfections and to enable me to feel still further that I have your sustenance in these matters connected with our profession. I am deeply interested in them and have been so for nearly sixty years. I shall not be troubled that way sixty years longer. Accept my thanks I pray you."

We have thus followed the career of Dr. WALTER from youth to revered old age. His position in American architecture is a proud one. As he modestly puts it himself in the above address: "I began with you almost at the beginning and have done the best I could."

As an architect and scholar, Dr. WALTER's professional learning was deep and well digested. In style of architectural composition, pure, artistic and dignified. In social

life he was ever the cultured gentleman. In personal appearance, venerable and commanding.

"Truth in art," was the key-note in his professional career; the fundamental law which he laid down for himself and the burden of all his writings and public utterances. "Let us live," he once said, "for the promotion of our art. Let us leave no stone unturned to devise throughout the world the elements of a pure and correct taste."

One more quotation from Dr. WALTER's addresses to the Institute and I will close this memoir. The last words of his annual address of 1880 speak the whole life of the man. No stronger or more heartfelt words could come from the lips of the Nestor of American architects.

"We owe it to our country, to the age in which we live, to our family, to ourselves, to devote the rapidly fleeting hours of our lives to the accomplishment of the greatest possible good in our vocation; ever seeking to discharge our duties in all good conscience towards those whose interests are intrusted to our care, towards co-workers in the realm of art, and towards Him in whom we live and move and have our being."

BOOK NOTICES.

A MANUAL OF DESCRIPTIVE GEOMETRY, WITH NUMEROUS PROBLEMS. By Clarence A. Waldo, A.M., Professor of Mathematics, Rose Polytechnic Institute, Terre Haute, Ind. Boston: Published by D. C. Heath & Co. 1888.

This handy little volume of seventy-seven greatly condensed pages might perhaps have been more appropriately entitled "A Collection of Exercises in Descriptive Geometry."

The author states, in his preface, his belief that to accomplish the purposes of Descriptive Geometry, "nothing is better than problems of progressive difficulty, which, taken in their logical order, the student can master alone, or with the aid of a small amount of judicious suggestion." Accordingly, a very brief introduction, stating only the broad features of the subject and the author's system of notation, is immediately followed by Part I, forming the major portion of the work and composed "exclusively of problems systematically arranged."

Part II contains "suggestions, analyses and occasional demonstrations," and Part III (very brief) "is a condensed statement designed for occasional

reference in the earlier part of the work, but especially as a review before leaving the subject or in preparing for examination."

Among the special features enumerated by the author is "the omission of all plates except a few of a generic character," but we are not told what advantage is to accrue from this omission.

The work evidences much care in its preparation, and the very thorough drill which its many exercises must give can hardly fail to be of great service to the student.

T.

TABLES OF THE PROPERTIES OF SATURATED STEAM AND OTHER VAPORS.

By Cecil H. Peabody, B.S. New York: John Wiley & Sons. 1888.
8vo, pp. 3 to 25 text, 1 to 35 XIII tables.

This work contains the result of a set of calculations to determine the pressure, temperature and other properties of saturated steam, founded on the experiments of Regnault, and gives in full the data and methods of calculation. The constants obtained in the general equation—

$$p = a + b a^n + c \beta^n,$$

representing the relation between the pressure and temperature of saturated steam vary, generally in the thousandths place, slightly from those usually given, making some changes in the tables.

Thus Buel's tables give for

$$p \text{ (pressure)} = 15 \text{ pounds (absolute),}$$

$$t \text{ (temperature)} = 213.067^\circ \text{ F.,}$$

while Peabody gives

$$t = 213.03^\circ \text{ F.}$$

For $p = 30$,

Buel gives

$$t = 250.293^\circ \text{ F.};$$

Peabody,

$$t = 250.27^\circ \text{ F.}$$

For $p = 100$,

Buel gives

$$t = 327.625^\circ \text{ F.};$$

Peabody,

$$t = 327.58^\circ \text{ F.}$$

Rowland's experiments on the mechanical equivalent of heat are given and its value is given as 778 for 45° latitude and at the sea level.

From a combination of Rowland's and Regnault's experiments, the specific heat of water varies for each 5° C. , beginning 0° to 5° , in the following order:

1.0072, 1.0044, 1.0016, 1.0000, 0.9984, 0.9948, 0.9954, 0.9982, 1.0000; from 45° to 155° C. , 1.008; from 155° to 200° C. , 1.046.

Investigation of the formula for the total heat of saturated steam has shown that the one ordinarily used—

Total heat = $606.5 + 0.305 t$ for French units
represents our best knowledge on the subject.

The results of Tate and Fairbairn's attempts to determine the specific volume of steam by direct experiment, are compared with the results obtained by the thermo-dynamic method, and are shown to be less correct.

The equations expressing the relation between the temperature and the pressure, heat of the liquid, total heat, and the heat equivalent of internal work are given for the vapors of alcohol, ether, chloroform, carbon disulphide, carbon tetrachloride, acetone, sulphur dioxide and ammonia and from them Tables IV to XI are computed.

For saturated steam three tables are given. Table I in English units for every degree Fahrenheit from 32 to 428; II for every pound pressure from 1 to 336; III in French units, for every degree Centigrade from 0 to 220.

Table XII gives the specific gravity, water at 4° C. being the standard, and the specific volumes of the liquids above mentioned, and Table XIII gives the volume of water from 10° to 200° C.

The evident carefulness with which the work has been done, the convenient form in which it is issued, and its containing, as it does, the most recent experiments, will make it the standard reference book for tables of saturated steam. The tables are nicely arranged for use, and could only be improved by putting fifty numbers on a page instead of thirty-nine or forty. H. W. S.

A FEW INCIDENTS IN THE LIFE OF PROF. JAMES P. ESPY. By his niece, Mrs. L. M. Morehead. Cincinnati: Robt. Clarke & Co. 1888.

A brief but very interesting memoir with this title has been sent to the FRANKLIN INSTITUTE by its author, which is intended primarily to correct some errors that have received currency through careless or sensational writers. It is a grateful duty to welcome this correction, and to join this lady author in a tribute of respect to one of the ablest, most earnest and sincere of all the students of natural science this country has known. He was especially an associate and co-worker with the FRANKLIN INSTITUTE, and an active and influential member for many years. Here he began his correspondence with scientific men, both of this country and of Europe, which enlisted universal attention, and received at that time almost universal assent to the theory he propounded. It is certainly remarkable that so much attention should be drawn to the observation of atmospheric phenomena as was done by the lectures, efforts and experiments conducted by Prof. Espy at the FRANKLIN INSTITUTE, and where he appealed to the general government for aid to conduct and enlarge his work. He had the name of every man prominent in science in this country to support his applications. He obtained the establishment of a system of meteorological observations in the state of Pennsylvania in 1839, which was before the organization of the Smithsonian Institution, and led to the appointment of Prof. Espy to the position of meteorologist to the Navy Department—not to the War Department, as the author of

this memoir supposes—in 1847. Prof. Espy was, under this appointment, to investigate the theory of storms, to invite the co-operation of private observers, and to report from time to time to the Secretary of the Navy. He did so make three general reports, to the last of which, published in 1851, a large number of folio charts are attached, giving the observations received by him, as taken simultaneously at a large number of stations. These were the proper forerunners of the signal service charts now in use. Prof. Espy's theory of storms has scarcely been sustained by the full course of observations now available for this discussion, and it is found that while several theories have a few storms in each year to represent them, no one form of atmospheric movement is common to them all. It is due to Prof. Espy to say that he often expressed the earnest wish that his researches should stimulate others rather than to be taken as being committed to any theory. He was as liberal in his views as he was energetic in prosecuting them, and contended only for what he saw or fully believed.

The lady who writes this memoir claims no more than is justly due to the memory of the most energetic and conscientious scientist of his time, who sought results by the highest and most comprehensive methods, who directed the use of accurate instruments in making faithful records, the results of which other students of physical science could use as well as himself. He induced the Smithsonian Institution to establish a system of observation, which produced a great body of materials for a climatology. And this was followed first by the Department of Agriculture and next by the Signal Service Bureau.

Mrs. Morehead's memoir is only too brief; it might very well have been more explicit on some points of his personal history, which no biographer has so far given. The absurdities of Perley Poore's pretended reminiscences should be counteracted by an authentic life of this really able and remarkable man, who displayed unprecedented energy in opening up a new field of scientific research. If he did not attain success in verifying his theory of storms, he at least commanded respect and enlisted attention to a degree that had never been equalled at that time.

It is pleasant to read in this brochure of the honorable origin and early associations of Prof. Espy, of his high standing as a student in the University of Kentucky at the time when Perley Poore falsely reports that he "could not read at the age of seventeen," from which University he duly graduated, subsequently studied law, and later became a professional teacher in Philadelphia. The older members of the FRANKLIN INSTITUTE should remember Prof. Espy, who was, perhaps, the most active one among its members for many years, until his removal to Washington about 1851.

Philadelphia, September 27, 1888.

LORIN BLODGET.

PREPARING FOR INDICATION; PRACTICAL HINTS. By Robert Grimshaw. New York: Practical Publishing Company. 1888. pp. 56.

This little work, by Mr. Grimshaw, covers the ground suggested by its title completely, and should be in the hands of every one desiring a practical knowledge of the methods of going to work to prepare for taking indicator

cards. The work is divided into chapters, covering the methods of attachment to the cross-head, ceiling or floor, the main lever, the card lever, and the proper place and how to run the piping. Every engineer doing a general consulting business, has felt the necessity of some such set of general directions, which he can send in advance of his going to test an engine and thus save the annoyance and delay of doing this work after he arrives on the ground, and this little book seems to be just what is desired. A few more words in a few places, particularly in referring to the substitute for the slotted lever, might have made the matter clearer, but generally the directions are simple and easily understood, and any one in charge of an engine should be able intelligently to make all the preparation needed from the instructions given.

H. W. S.

THE DESIGNING AND CONSTRUCTION OF STORAGE RESERVOIRS. By Arthur Jacob, B.A., late Executive Engineer for Irrigation, H. M. Bombay Service. Revised and extended by E. Sherman Gould, M. Am. Soc. C.E., Consulting Engineer to the Scranton Gas and Water Company. New York: D. Van Nostrand, Publisher, 23 Murray Street and 27 Warren Street. 1888.

Mr. Jacob's well-known little book now appears with some additional remarks by Mr. Gould, who observes, in his brief preface, that "it was considered best, in view of the standard character of the work, to present it in its original form, with all additional matter separate from the text. All of the editorial work, therefore, in the present volume, appears in the shape of foot-notes, and the additional pages appended to the original discussion."

The "notes" are few, and generally brief, constituting a running comment upon isolated statements by the author.

The "additional remarks," covering some thirty pages, contain the editor's views as to what constitutes the best practice in this branch. In these, while highly approving the author's work in the main, the editor naturally differs from him in many particulars, chiefly in those where American practice differs from the European.

T.

AN ELEMENTARY COURSE IN DESCRIPTIVE GEOMETRY. By Solomon Woolf, A.M., Professor of Descriptive Geometry and Drawing in the College of the City of New York. New York: John Wiley & Sons, 15 Astor Place. 1888.

A most scholarly and conscientious work, both precise and concise (yet ample) in treatment. The language is clear and thoughtful, the arrangement methodical and natural. The work is very thoroughly and beautifully illustrated. The cuts number 289, and most of them are models of clearness. What is of prime importance, they are well *lettered*, apparently being done by the "wax process," which admits of lettering in *type*.

The book is admirably printed on excellent paper, and in the clearest of type. In short, it is, in all respects, a pattern of what a text-book ought to be.

T.

SCIENTIFIC NOTES AND COMMENTS.

CHEMISTRY.

AN ELECTRO-CHEMICAL ACTINOMETER.—Gouy and H. Rigollet (*Comptes Rendus*, **106**, 1470). A clean copper plate is heated over a Bunsen burner until the iridescence which first appears is replaced by a uniform tint, the surface then consisting principally of cuprous oxide. The plate may then be preserved from further change by coating with paraffin while still warm. When such a plate is placed with another plate of unoxidized copper in a solution of sodium chloride, an electromotive force of a few hundredths of a volt is developed. On exposure to light, the electro-motive force increases, the oxidized plate becoming more strongly positive. The effect is instantaneous, and ceases as soon as the light is cut off. The variation in the electro-motive force is greater when the circuit has a resistance of several hundred ohms; thus with a Thomson galvanometer a candle flame produces a sensible effect at a distance of several metres. Instead of an oxidized and a clean copper plate, two oxidized plates may be used, only one being exposed to the light. The couple appears to be sensitive to all visible rays.

W. H. G.

DETECTION OF COMMERCIAL SACCHARINE IN ARTICLES OF FOOD.—E. Bornstein (*Zeit. Anal. Chem.*, **27**, 165).—The test is based on an observation of Remsen's, that when a minute quantity of saccharine is heated in a test-tube with a little resorcinol and some strong sulphuric acid, the mixture becomes yellow, then red, and finally deep green, sulphur dioxide being at the same time disengaged with effervescence. On cooling, the solution is diluted with water, and an excess of alkaline hydroxide added: the liquid now appears red by transmitted light, but has a strong green fluorescence. A milligramme of saccharine will yield six litres of fluorescent solution. In applying the test to articles of food, the substance is slightly acidified, preferably with phosphoric acid, and is then extracted with ether, the evaporation of the ether leaving the saccharine sufficiently pure for the reaction. Any fat present is removed with petroleum spirit before the extraction with ether.

W. H. G.

ON THE PURIFICATION OF MERCURY.—J. M. Crafts (*Bul. Soc. Chim.*, **49**, 856,) finds that mercury may be purified in large masses by the simple aspiration of air through it. He places the mercury in a glass tube 5 cm. in diameter and 1.5 m. long, lying on an inclined wooden support. The lower end is closed by a cork through which pass a funnel tube for the introduction of the mercury, and a stop-cock for its removal. The other end is put in communication with a water exhaust pump, and in forty-eight hours all the impurities will be found as a coherent powder in the upper end of the tube, and the mercury can be drawn off practically pure. This powder is too voluminous in the case of mercury that has been used to amalgamate zinc to permit the process to be at once used for such metal. Zinc and lead were

introduced into mercury that had been previously purified by distillation in a vacuum, and, after purification by a current of air, it left no residue when again distilled in a vacuum.

W. H. G.

ON THE PROTECTION FROM RUST OF RAILROAD RAILS IN ACTIVE SERVICE.—W. Spring (*Bull. Soc. Chim.*, **50**, 215) believes that the apparent immunity from rust of rails in active service while unused rails soon become thickly covered with rust, is due to the combination, under the pressure of the wheels, of ferric hydrate with the iron of the rail, thus forming magnetic oxide, which protects the iron from further action. This theory is supported by the results of experiments in which thin iron plates were covered with moist ferric hydrate and the mixture subjected to 1,000 atmospheres pressure. The ferric hydrate was blackened and adhered strongly to the plates, which were corroded; the substance next the iron of the plates was found on analysis to be at least in part magnetic oxide. The conditions of the experiment were such as are actually present in the case of rails: the rust which forms on the rails after a rain or during damp weather has rarely the time to become dry before the passage of a train converts it into magnetic oxide. For further proof, the scales on that surface of a rail which received the greatest pressure were removed by the aid of a brass wire brush and submitted to analysis. They were found to be composed of magnetic oxide mixed with a variable quantity of ferric oxide and apparently a small proportion of free iron.

W. H. G.

CUTCH AND GAMBIE.—Henry Trimble (*Am. Jour. of Pharmacy*, **60**, 497). Read before American Pharmaceutical Association, September, 1888.

Six samples, three of cutch and three of gambier, were analyzed, with the following results:

	CUTCH.			GAMBIE.		
Samples No.	1	2	3	4	5	6
Catechin, ...	2'80	1'70	10'70	12'64	7'76	19'76
Catechu-tannic acid, .	31'94	33'54	25'50	33'34	47'18	45'90
Total valuable constituents, ...	34'74	35'24	36'20	45'98	54'94	65'66
Mucilage, ...	27'40	29'01	20'50	10'13	15'20	16'03
Ash, ...	2'29	2'27	2'10	4'74	3'37	3'50
Moisture, ...	12'50	12'20	15'36	10'33	11'03	9'90
Coloring and other inert matter, ...	23'07	21'28	25'84	28'82	15'46	4'89
•	100'00	100'00	100'00	100'00	100'00	100'00

The method of examination was to separate catechin, by agitating the aqueous solution with ether, then treat portions of samples with "hide powder," according to the method of Simnad and Weiss (*Dingler's Polyt. Jour.*, **260**, 564), which gave the catechu-tannic acid.

It has long been a statement in text-books that cutch and gambier are identical in chemical composition. It has, however, never been proven, and

I am convinced that it is entirely erroneous. In the above samples, no crystallized catechin could be obtained from samples 1 and 2, and only a small quantity from 3, while it readily crystallized from the aqueous solution of the ethereal extract of gambier. Both the physical appearance and the analysis indicate that there are important differences in the coloring matter of the two. This is further emphasized when we consider their respective commercial uses. The tanner selects gambier for his purpose because he wishes tanning material without color; the dyer prefers cutch because he wants coloring matter as well as tannin, the color in some cases being the more important of the two.

From the published accounts of the methods of preparing these two drugs, it is impossible to believe they could be chemically identical.

Apart from their different botanical origin, the long-continued heating necessary to extract cutch from the hard heart-wood is so different from that required to exhaust the more porous twigs and leaves of the gambier, that the evaporation in the case of the cutch is carried directly to dryness, the decomposition products being such as to prevent the "setting" of the mass as it does in the case of the gambier.

In the latter the concentration of the liquor is stopped when it reaches the consistency of syrup, and the liquid by stirring and cooling "sets" on account of separation of catechin, becoming of such solidity that it can be cut into blocks, and further dried at such a low temperature that comparatively little change takes place. When gambier comes in cubes it precludes a kind of adulteration which is extensively carried on with cutch, namely, the admixture of small stones, pieces of earthenware and bricks.

Such adulteration is liable to be overlooked in selecting samples for analysis, and is best indicated when a large lot is powdered and portions of this analyzed.

Two samples of powdered cutch were examined, and yielded 14.01 and 18.20 per cent. of ash, which were made up of sand and crushed stones. These samples had been further reduced in value by the heat necessary to dry them previous to powdering, as is indicated by the following percentage results obtained by treatment with ether and alcohol.

Samples No., ...	8	9
Soluble in ether, ...	0.90	8.75
Soluble in absolute alcohol, ...	9.93	17.50
Total valuable constituents, ...	10.83	26.25
Mucilage, etc., ...	47.30	29.10
Ash, ...	14.01	18.20
Moisture, ...	14.10	7.30
Insoluble, ...	13.76	19.15
	100.00	100.00

Gambier in cubes could not be so adulterated, and it is so dry as to be readily powdered without previous heating to expel moisture. It is stated that gambier is adulterated by the addition of clay, but this admixture is

probably not more common than it is with cutch ; in both it may be detected by the amount of residue left on burning. W.

THE ACTION OF MERCURY ON PLATINUM.—Crafts (*loc. cit.*).—Thin platinum foil is unattacked by cold mercury, but after long boiling in a flask sealed to prevent the admission of air, the foil is gradually corroded. The platinum is only partially dissolved by the mercury, the greater part of that which disappears separating in the form of a black powder, which is nearly all held in suspension. The surface of the mercury remains clean, but if a current of air be drawn through it, the platinum powder collects together, and if the mercury be then distilled, a very small residue of platinum is found.

W. H. G.

ON THE CAUSE OF METALLIC LUSTRE.—W. Spring (*Bul. Soc. Chim.*, **50**, 219). Dove was the first to attempt an investigation of the physical circumstances that are concerned in the production of metallic lustre. He had examined, by the aid of a stereoscope, two images of a pyramid, one being colored blue and the other yellow, expecting to find a relief image of a green color ; he was, however, astonished to find that the mixture of colors gave a reflection like that of a polished metallic surface. Having repeated the experiment, using a black and a white image, he obtained the metallic gray of lead and tin. From these experiments, Dove concluded that metallic lustre is due to two reflections from superposed surfaces, and that the accommodation of the eye being different for each color, a perfect coincidence of the images of different colors was impossible. The lustre of metals would thus be caused by a reflection from the actual surface, and another from beneath the surface.

This explanation attributes a considerable degree of transparence to the metals, more indeed than seems consistent with fact. Brücke offered another theory, according to which the color of light reflected from bodies not possessing the metallic lustre should be independent of the local color ; that is, the color of the reflecting body ; while in the case of metals the color of the reflected light is that attributed to the substance, the incident light being white. Brücke also considered that a certain intensity of reflection was a necessary condition for metallic lustre, this intensity resulting from the opacity of the metals, and he mentions the phenomenon of total reflection as producing a perfect imitation of metallic lustre.

The theories of Dove and Brücke represent opposing views of the transparency of the metals: the one considers them as opaque, the other as transparent. The author endeavors to reconcile these views by a study of the nature of the surfaces of the solids he has obtained during his experiments on the compression of solids within polished steel cylinders. He finds that substances which in the form of powder are opaque, produce solids that have a metallic lustre, whatever the nature of the substance ; while such substances as yield powders more or less transparent formed cylinders having *vitreous* surfaces, looking as if varnished. Between the vitreous lustre and the most perfect metallic lustre there are all the degrees that could be made between opaque and transparent substances, the greatest metallic lustre being devel-

oped when there is the greatest opacity. The metallic lustre then depends on the physical condition of the substance and not on its specific chemical nature. A metal which could exist in an allotropic form having a certain transparency would be capable of assuming a vitreous lustre. W. H. G.

THE WELDON-PECHINEY PROCESS FOR THE MANUFACTURE OF CHLORINE. —J. Dewar (*Jour. Soc. Chem. Ind.*, **6**, 775, through *Jour. Chem. Soc.*, **54**, 411). This process has been worked at Salindres in an experimental plant, designed to produce a ton of chlorine daily. The process consists (1) in dissolving magnesium oxide in hydrochloric acid; (2) making magnesium oxychloride; (3) crushing, breaking and sifting the oxychloride; (4) drying the oxychloride; (5) decomposing the oxychloride by heated air, magnesium oxide being left to again go through the first operation. The solution of magnesium chloride is evaporated so that it contains not more than six equivalents of water, and is then converted into oxychloride by mixture with one and a third equivalents of magnesium oxide. The mass becomes very hard and disengages much heat during solidification, although the operation lasts but about twenty minutes. The pieces are crushed into fragments about the size of a walnut, and these are freed from dust by passing through a rotating sieve. The oxychloride is then dried, and introduced into a special apparatus consisting of a series of furnaces having decomposing chambers heated by a movable regenerative burner. In the first stage of the decomposition there is a rapid evolution of steam which decomposes a part of the oxychloride forming hydrochloric acid that passes off with the water vapor. The resulting mixture of anhydrous magnesium chloride and magnesium oxide is decomposed by the oxygen of the air at the high temperature, only magnesium oxide remaining. The products are drawn from the furnace by an aspirator and passed through a hydrochloric acid condensing tower for the retention of the acid at first disengaged—and this is used in the first operation, together with more obtained by the decomposition of salt—while the mixture of air and chlorine passes on and is used for the manufacture of chlorate. W. H. G.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Agricultural Experiment Station of the University of Wisconsin. Fifth Annual Report. From the Station.

American Academy of Music. Thirty-fifth Annual Report.

From the Board of Directors.

American Ephemeris and Nautical Almanac for 1891.

From the Bureau of Navigation.

American Philosophical Society. Transactions. Vol. 16. Part 2.

From the Society.

- American Society of Mechanical Engineers. Transactions. Vol. 9.
From the Society.
- Armstrong, William, and others. Recent discussions on the abolition of
patents for inventions. From Mr. R. A. Macfie.
- Baker, Henry B. Recent Advances in State Medicine.
From the State Board of Health of Michigan.
- Barus, Carl. Maxwell's Theory of the viscosity of solids and certain
features of its physical verification. 1888. From the Author.
- Boiler Explosions Act, 1882. Report of the President of the Board of Trade
upon the working of the act, from June 30, 1886, to June 30, 1887.
From the Manchester Steam Users' Association.
- Boston Society of Civil Engineers. Report of the Committee on Weights
and Measures. From the Society.
- Boye, Martin H. A Treatise on Pneumatics. Philadelphia, 1855. 8 vo.
From Dr. Isaac Norris.
- Canada. Statistical abstract and record for 1886 and 1887.
From Mr. G. H. Fawcett, Customs Department.
- Clayton Air Compressor Works. Catalogue No. 6. From the Works.
- Department of Agricultural Division of Entomology. Bulletin No. 19.
Periodical Bulletin, No. 3.
Forestry Division. Bulletin, No. 2.
Report of the Statistician. No. 55. From the Department.
- Department of Public Instruction of the State of New York.
Annual Reports of the State.
Superintendent for 1879 to 1887.
Designs for school-houses. 1888.
General school laws of the State. From the State Superintendent.
- Department of State, U. S. Reports from the Consuls of the United States,
May and June, 1888. From the Department.
- Deutsch-Amerikanischen Techniker Verbandes, Mittheilungen. August,
1888. From Dr. W. H. Wahl.
- Engineers' Society of Western Pennsylvania. Paper. From the Society.
- Gannal, J. N. History of Embalming. Philadelphia, 1840. 8 vo.
From Dr. Isaac Norris.
- Geological Survey of Pennsylvania. Annual Report for 1886, part 4 and
Atlas Aa, part 2. From the Survey.
- Gilbert, J. H. Results of experiments at Rothamsted on the growth of root
crops. From Profs. Gilbert and Lawes.
- Glasgow and West of Scotland Technical College Calendar, 1888-89.
From the College.
- Holly District Steam Engineers, Superintendents and Managers Associa-
tion Transactions during 1886-87. From the Association.
- Hydrographic Office. Pilot Chart of the North Atlantic Ocean. October,
1888. From the Office.
- Illinois State Board of Health. First, Seventh and Eighth Annual Reports.
Proceedings of the meeting, April, 1885. From the Board.

- Illinois State Laboratory of Natural History. Articles 2, 3 and 8.
From the Laboratory.
- Institution of Civil Engineers. Minutes of proceedings. Vol. 94. Brief subject index. Vols. 59 to 94. From the Institution.
- Iowa. First to Third Biennial Reports of the State Mine Inspector for 1882 to 1887. From J. E. Stout, Inspector Third District.
- Iron and Steel Institute Journal No. 1. 1888. From the Institute.
- Jordan, David S. Darwinism. Chicago, 1888. From the Author.
- Koschnitzki, Michael. Ueber die Einwirkung von Brom.
From the Technical High School, Karlsruhe.
- Lawes, J. B. Memoranda of the origin, plan and results of the field and other experiments. From Profs. Gilbert and Lawes.
- Lobdell Car Wheel Company Catalogue of Car Wheels.
From the Company.
- Magnetical and meteorological observations, made at the Government Observatory, Bombay, for 1886. From the Observatory.
- Maine. First to Third Annual Reports of the State Board of Health, for 1885 to 1887. From the Board.
- Manchester Association of Engineers. Paper and communications; also Thirty-second Annual Report of the Council, 1887.
From the Association.
- Manchester Steam Users' Association. Report of the Proceedings at the Annual Meeting, 1888. From the Association.
- Mason, G. C., Jr. Thoughts on Architecture. 1879. From the Author.
- Michaelis, K. W. and O. E. Alfred Krupp, His Life and Work.
From Thomas Prosser & Son.
- Michigan State Board of Health. Fifteenth Annual Report of the Secretary.
From the Board.
- Morton, Thomas G. Imperfect Symmetry. From the Author.
- New York City. Department of Public Works. Reports for the quarter ending March 31st, June and September 30, 1886, for the year 1887, and quarter ending March 31, 1888. From the Department.
- Ohio Agricultural Experiment Station. Bulletin No. 6. Second series.
From the Station.
- Otten, G. Ueber ein Erdöl aus Argentinien.
From the Technical High School, Karlsruhe.
- Pasquay, Carl. Ueber die Einwirkung von Carbonylchlorid.
From the Technical High School, Karlsruhe.
- Patent Law of the Republic of Switzerland. From Wirth & Co.
- Patent Office, British. Specifications of Inventions. Vols. 66, 69, 71 to 86 of 1886; Vols. 1 to 16 of 1887. Name Index, 1887; Subject Index, 1887.
From the Office.
- Patent Office, U. S. Specifications and Drawings. March to June, 1887.
From the Office.
- Pennsylvania Annual Report of the Superintendent of Public Printing and Binding, 1887. Report of the State Librarian, 1886.
From the Librarian of Senate.

Pensions. Report of the Commissioner for 1888. From the Commissioner.
 Royal Society of Canada. Proceedings and Transactions. Vol. 5.

From the Society.

St. Louis. Annual Report of the Health Commissioner for 1887-8.

From the Commissioner.

Signal Office. Daily International Chart, August, 1887. Summary and
 review of observations, August 1887. From the Office.

Spilsbury, E. G. Wire rope tramways for economical purposes.

From Cooper, Hewitt & Co.

Stevens, W. LeC. The quality of musical sounds. From the Transactions
 of the New York Academy of Sciences. From the Author.

Surgeon-General's Office. Index Catalogue, Vol. 9.

From the Surgeon-General.

Technische Hochschule zu Karlsruhe. Programme, 1888-9.

From the School.

U. S. Antimony Company Prospectus.

From Mr. Chas. Bullock.

U. S. Coast and Geodetic Survey.

One hundred and eighteen Coast and Miscellaneous Charts published
 since May, 1883.

Catalogue of Charts, 1887.

From the Survey.

United States Geological Survey Atlas, to accompany a Monograph on the
 geology and mining industry of Leadville, Col., by Samuel Franklin
 Emmons. From the Survey.

Verein für Erdkunde zu Metz. 10ter Jahresbericht. From the Society.

Wieler, A. Ueber den Antheil des Secundären Holzes der dicotyledonen
 Gewächse. From the Technical High School, Karlsruhe.

Wirth, Franz. Die Patent Reform.

From the Author.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, October 17, 1888.*]

HALL OF THE INSTITUTE, PHILADELPHIA, October 17, 1888.

Mr. JOS. M. WILSON, President, in the Chair.

Present, 213 members and thirty-six visitors.

Additions to membership reported, two.

The President, in conformity with a resolution of the Board of Managers,
 presented and read a carefully prepared statement of the financial condition
 of the INSTITUTE, which exhibited the fact that the current income was insuffi-
 cient to meet the current expenses, and that the usefulness of the INSTITUTE
 is, and for years has been, seriously hindered by reason of insufficient means.

The President's report was accepted, and, on motion of Mr. H. R. HEYL, was ordered to be the subject of special consideration at an adjourned meeting, to be held on Wednesday, October 24th.

The Secretary read a letter from Mr. JOHN LUCAS, accepting election as a member of the Board of Managers.

Capt. H. C. TAYLOR, U.S.N., General Manager of the Nicaragua Canal Construction Company, thereupon read a paper on the "Inter-oceanic Canal across Nicaragua." The paper, which was clearly illustrated by maps, diagrams, etc., embraced a historical sketch of the many plans that have been proposed for building a ship canal across the American Isthmus, and an account of the leading features—engineering, political and commercial—of the project of the company above named.

The meeting passed a vote of thanks to Capt. TAYLOR for his most interesting presentation of the subject. The paper called forth an animated discussion. Referred for publication.

Mr. CARL HERING thereupon exhibited and described several interesting and ingenious electrical and mechanical novelties on behalf of Mr. ABDANK-ABAKANOWICZ, of Paris. They included :

ABDANK'S magnetic call ; an electric bell without battery ;

CARPENTIER'S electrical time-beater for divided orchestras or choruses ;

CARPENTIER'S melograph and melotrope, intended for recording music electrically, and for reproducing the same mechanically, on the piano ; and

SERPOLET'S instantaneous, safety, steam generator ; a new form of steam boiler.

The Secretary read a communication from Mr. W. N. JENNINGS, setting forth his claims to have been the first to have observed and announced, upon the evidence of photographs of lightning flashes, that the course of these flashes exhibited, not a zigzag, but a wavy line. Mr. JENNINGS presented a series of his lightning photographs from 1882 to the present time, arranged in chronological order, and referred in his communication, to the fact that all but the latest had been shown and described at the meetings of the INSTITUTE, and that the specific observation above-named had been repeatedly referred to on these several occasions. Mr. JENNINGS'S communication was referred to the Committee on Publications.

The Secretary, in his report, described and exhibited a picture of the interesting specimen of "pontoon" bridge, lately thrown across the Missouri River, at Nebraska City, Neb., of which an account appears in the October impression of the JOURNAL. He also described, from notes furnished by Mr. DAVID R. WALKER, Chief of the Electrical Bureau of the City of Philadelphia, the system now in course of execution by the Philadelphia Bell Telephone Company, of arranging the telephone lines underground.

Whereupon the meeting was adjourned.

WM. H. WAHL, *Secretary.*

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI.

DECEMBER, 1888.

No. 6.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

AN INVESTIGATION OF THE CONSTRUCTION OF THE VARIOUS KINDS OF CUPOLAS THAT HAVE BEEN USED FOR THE MELTING OF PIG-IRON.

BY M. A. GOUVY, JR.*

Translated by W. F. Durfee, Engineer.

The translator, regarding the paper of M. Gouvy as of great value to all manufacturers of iron and steel, inasmuch as it presents, in one comprehensive view, most of the experiments that have been tried in many lands, with a hope of improving the working of cupolas, offers to English readers the substance of it, in the belief that, if its conclusions are intelligently followed by users of cupolas, very large economies will result; for his own investigations,

* Étude sur les cubilots pour la fusion de la fonte. Par M. A. Gouvy Fils," published in "Mémoires et compte rendu des travaux de la Société des Ingénieurs Civils." Paris, 1887. pp. 723-766.

many years ago, led to the conclusion that the most of the cupolas then in use in this country, wasted three-quarters of the fuel put into them, and that there were but very few, indeed, that utilized one-half; conclusions which observation in recent years has furnished no reason to change.—W. F. D.

PURPOSE OF THE PAPER.

It is intended in this paper to glance cursorily over the successive improvements which have been made in the construction of cupolas for the fusion of pig-iron, since their use has become general in metallurgy, and to give some information relative to certain special methods of construction which have been invented, based upon principles more or less understood, and to describe a few of the more recent forms of apparatus which have attracted the most attention from metallurgical engineers. In these pages, therefore, will be found a description of the most important inventions relating to the cupola, as well as an account of the results obtained in most of the cases, together with a discussion of the value of the most important of the systems described.

I.

FIRST APPARATUS USED FOR THE FUSION OF PIG-IRON.

The first melting of pig-iron was accomplished probably in crucibles, which were heated by coal in a furnace in which the consumption of fuel was very great.

In order to avoid this inconvenience, those who first made castings from pig-iron had recourse to an apparatus similar to a cupola, called a "Calabash," which was fired either with coal or coke.

Valerius speaks of "calabashes" at Brussels* using coke, which consumed 77 to 88 pounds of coke for every 220 pounds of castings made, without counting the coal used for heating the "calabash," or the coke wasted.

The "calabashes" at Charleroi consumed 81.5 to 95 pounds of coke for each 220 pounds of iron melted, besides 2.7 to 3 per cent of coal; the waste of iron was not more than 5 to 6 per cent., as in ordinary cupolas.

* Valerius: "Traité de la fabrication de la fonte," 1851.

Reaumur describes the "portable calabashes," which we remember are still used in the country by the Gypsies for repairing saucepans.*

Among the more recent endeavors to augment the very small melting capacity of the "calabashes" we find the cupola, originally invented by Wilkinson (1790) and called a "shaft furnace," or "cupola."

The first stationary furnaces were provided with "shafts" or "cupolas" of masonry at their tops, from which the gas escaped, and it is probable that from this construction we derive the name ("cupola") in common use at the present time.

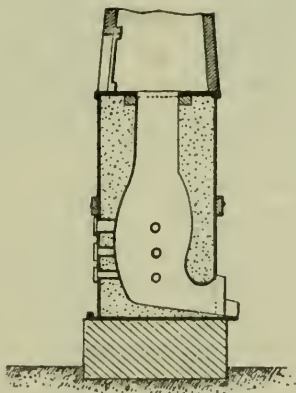


FIG. 1. Cupola with Rammed-up Walls.

These cupolas were of very primitive construction, having but a single tuyere, and their shafts either rectangular, oval or circular, in cross section, their walls being formed of refractory sand rammed into a casing of cast iron, a construction which required frequent repairs. Their height was not often more than five or eight feet. Charcoal was used as a fuel, and the quantity consumed was exceedingly great, often, in fact, amounting to fifty per cent. of the very small production of the furnace.

A cupola of this kind is represented by *Fig. 1*.

*The making of castings from iron melted in crucibles and in "calabashes" is illustrated and described in Emanuel Swedenborg's "De Ferro," published in 1734. W. F. D.

A cupola was built at Seraing (about 1850) having rammed walls, which were repaired once in eight days, and entirely renewed every six weeks; the crucible or bottom being repaired three times per week. The product per hour was about one ton of castings, with a total consumption of coke in the neighborhood of twenty per cent. We must here observe, that, notwithstanding the improvement in the cupolas used in foundries at the present time, it is rare good luck if, in economy of coke, they attain or surpass the above figure.

In China, where industrial progress for a long time has been almost nothing, they use small furnaces eight feet in height, with about the same width, having an internal diameter of the crucible of two feet, and provided with a single tuyere.* These furnaces are charged with a mixture of ore, cast iron and charcoal; from which are produced cooking utensils of remarkable thinness and lightness.

Cupolas having superposed tuyeres.—For the purpose of accumulating a large quantity of iron in the crucible for the making of large castings, the primitive system of fixed tuyeres is replaced by a series of superposed tuyeres, which are opened successively, and the preceding tuyeres stopped, as the level of the bath of iron in the crucible rises. The cupola of a foundry in Berlin † (*Figs. 2 and 3*) is of this construction. The system was for a long time employed in France, and perhaps is still in vogue in some foundries (*Fig. 4*).

II.

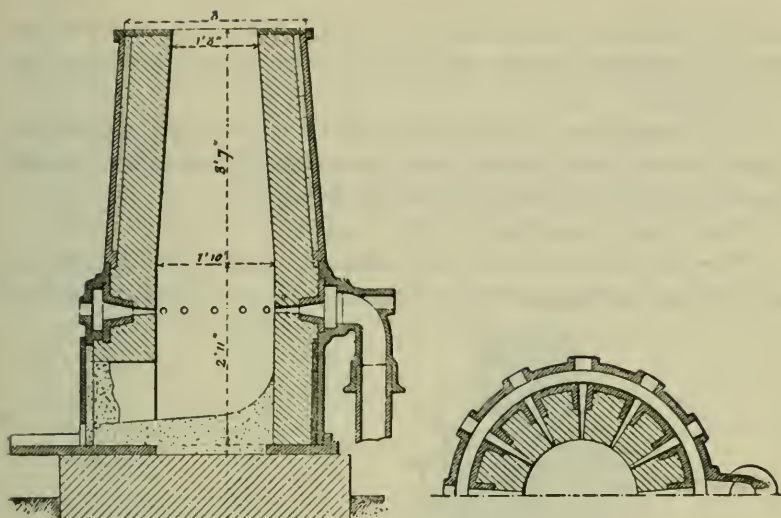
THE EMPLOYMENT OF HOT BLAST AND THE UTILIZATION OF THE GAS ESCAPING FROM THE TOP OF THE FURNACE.

Since the employment of cupolas in foundries has become general, a great number of patents for improvements have successively been issued.

A modification which was at first considered as of great importance, but afterwards gradually abandoned, consisted in the utilization of the gas wasted at the top of the furnace,

* *Chemical News.*

† Bruno Kerl: *Handbuch der Metallurgischen Hüttenkunde*, 1855.



FIGS. 2, 3. Cupola of the Foundry in Berlin.

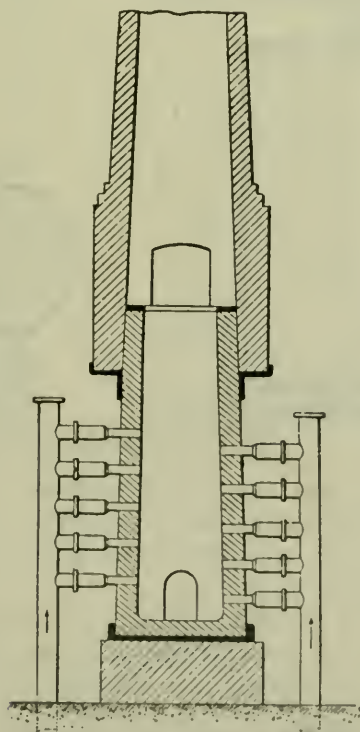


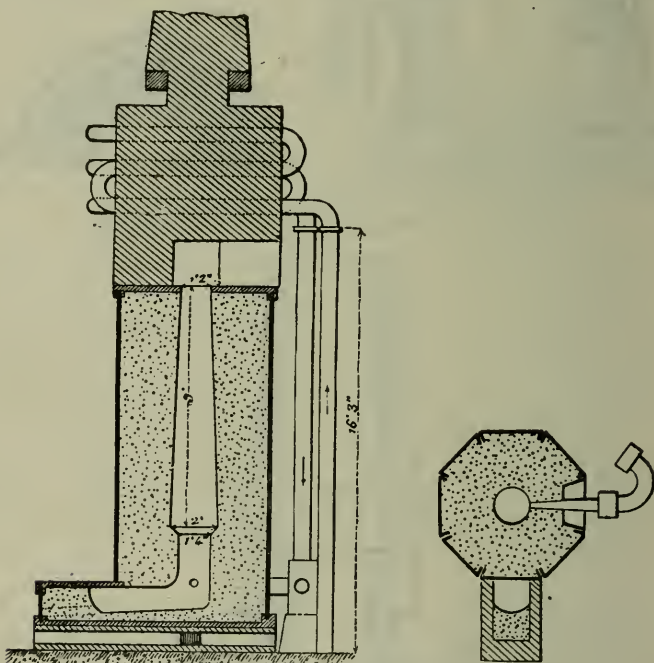
FIG. 4. Common French Cupola.

for the purpose of heating the blast, with a view of obtaining a larger production of castings with a smaller consumption of fuel.

Kerl* mentions, among others, a cupola employed in the Hartz, which was blown with air heated in U-tubes placed horizontally in its chimney (*Figs. 5 and 6*).

This cupola was fired with charcoal.

The same author also describes a furnace at Saynerhütte, which had an apparatus for heating the air. This consisted



FIGS. 5, 6. Cupola in the Hartz Mountains.

of two annular boxes connected together by vertical tubes, which were heated by the gas from the top of the furnace, and through which circulated the blast, which was thus heated to from 370° to 470° F.

Still, the use of the waste heat for raising the blast to a certain temperature was subject to the following inconveniences, viz: it was in fact difficult to place the appa-

* Bruno Kerl: *Handbuch der Metallurgischen Hüttenkunde*, 1855.

ratus above the cupola without greatly augmenting the cost of construction, and at the same time causing a back-pressure, which interfered with the normal working of the furnace; furthermore, the intermittent working of these foundry cupolas rendered it practically impossible to employ their gas for heating steam boilers as readily as in the case of blast furnaces.

We believe that the waste gas can be used for drying the coke intended for fuel, by passing it under cast-iron plates on which the coke is spread; another use would be to pre-heat the iron to be melted, which, having been placed in a small reverberatory furnace located on one side of the top of the cupola, is heated to a red heat and then pushed into the cupola.

All these methods were so complicated that they have been abandoned, and more simple arrangements have been sought for heating the blast without using the heat lost at the top of the furnace.

For this purpose Cabrol obtained a patent for a system by which the air was heated by actual contact with incandescent coal in a special closed chamber, thus charging the blast with carbonic oxide, and obtaining a very high temperature in the cupola.

Wright & Brown pass the blast, before it enters the furnace, around the melted iron. Although Kerl asserts that in Silesia they obtain by the employment of heated air a more rapid fusion, and with less waste of iron, it appears that these systems have not as yet given the results predicted by their authors; but have been successively rejected, either for the reason that their construction was too complicated, or from the absence of real advantages.

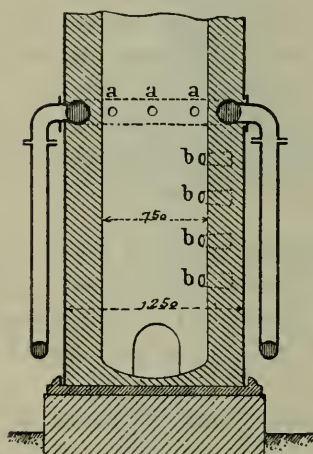
Nevertheless, these attempts have been continued in the same direction, and in 1871 Sir R. Mallet mentioned the Summerson cupola, which was blown with heated air.

The Ronchain Cupola.—Ronchain, of Maubeuge, patented, in 1885, a cupola having a passage for the blast within the masonry, in which the air was heated before it entered the cupola by the upper tuyeres (*Fig. 7*). The lower tuyeres were opened at variable heights according to the quantity

of iron in the crucible, in order to avoid exposing it to the action of the cold air.

Ronchain reports a consumption of twenty-two pounds of coke for the fusion of 220 pounds of iron, and about thirty pounds consumed before charging the iron.

The Woolwich Cupola.—At Woolwich there was a cupola that had a wind-box whose dimensions may be called enormous, as it extended from the tap-hole of the furnace



a . Hot blast.
b . Cold blast.

FIG. 7. The Ronchain Cupola.

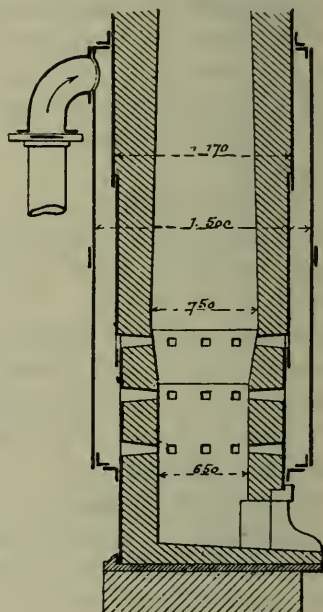


FIG. 8. The Woolwich Cupola.

almost to its top (*Fig. 8*). It had three rows of tuyeres, spaced one foot apart vertically.

We find also in Armengaud's publication* the description of a cupola having a wind-box (*Fig. 9*) communicating directly with the interior of the furnace by orifices which take the place of tuyeres. Such an annular box intended for heating the air is also employed by Voisin.

Tittl and Erndt's System.—Quite recently (in 1885) a detached crucible applied to a cupola, according to the

* Armengaud : *Publication Industrielle*. Vol. 22, p. 185.

system of M. Krigar, has been patented in Bohemia by MM. Tittl and Erndt.* In this system the blast traverses the tubes placed above the detached crucible, which are heated by the flame that passes out of the cupola through the lower orifice, and also by the radiation from the bath of melted iron (*Fig. 10*).

The Sheffield Cupola.—An arrangement which appears more practical than those already mentioned is described in "The Engineer"† as being employed in the Steel Works of Brown, Bayley & Dixon, at Sheffield.

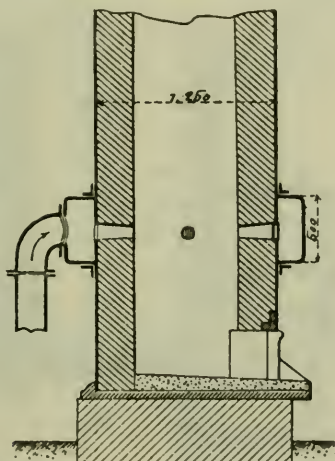


FIG. 9. Cupola with an Annular Wind-Box.

In this apparatus the blast pipes are connected to a series of sixteen U-tubes sixteen feet in height, having 1,700 square feet of heating surface; these are placed in two chambers located at the top of the chimney of a Bessemer Converter; the waste heat from the converter passes into these chambers, thus heating the blast intended for the cupolas, which are thirty-seven feet in height, and have two rows of tuyeres, placed one foot apart; the diameter at the tuyeres is four feet, and at the crucible five feet.

* *Dingler's Polytechnisches Journal*, 1885. Vol. 258, p. 445.

† *The Engineer*, 1879, p. 321.

The temperature of the blast is from 360° to 445° F., and we are told that the consumption of coke (for melting probably) is not more than 6.6 to 7 pounds per 100 pounds of iron melted.

Finally, we conclude that the employment of heated air for blowing cupolas, only results in an increase of their melting power in consequence of the elevation of the temperature of the zone of fusion; but we do not find any economy of fuel, which fact is attributable to the zone of fusion extending to a very much greater height than when

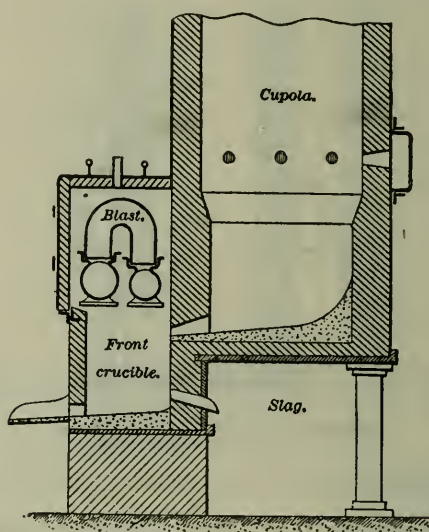
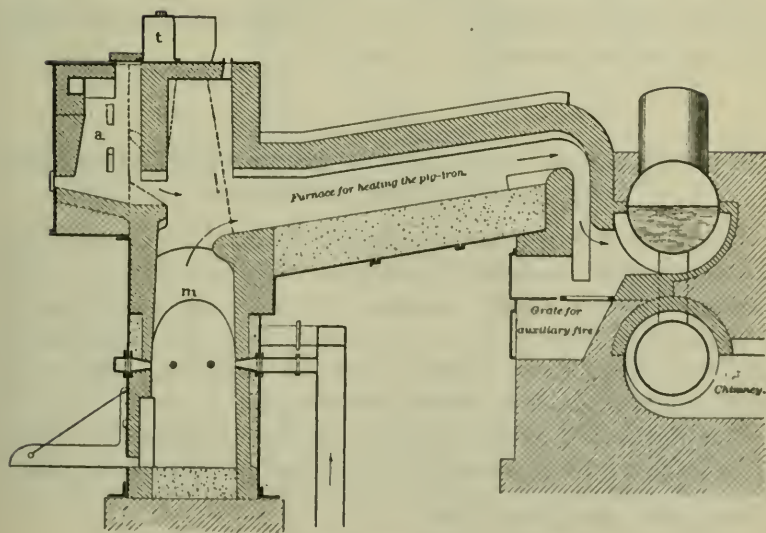
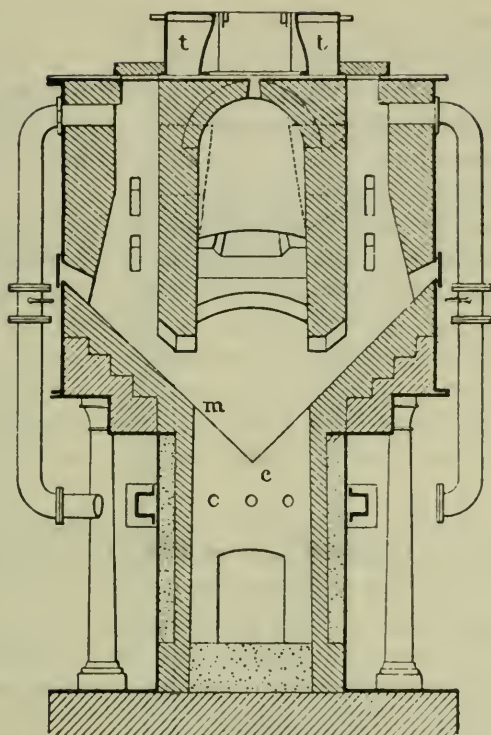


FIG. 10. The Tittl and Erndt, or Modified Krigar System.

cold air is used, and therefore the carbonic acid formed at the tuyeres encounters a very large surface of incandescent coke, which effects a reduction of this gas, and the advantages of heating the blast are annihilated by the loss of heat due to the transformation of this carbonic acid into carbonic oxide.

The Daelen Cupola.—Notwithstanding all the experiments that have been made without decisive results, M. A. Daelen recommends a very complicated German construction, which proposes to utilize the waste heat of the cupola, not



FIGS. 11, 12. The Daelen Cupola. (Scale 1-48.)

only for the fusion of the iron, but also for producing the steam necessary to drive the blowers.*

We will now describe this curious arrangement, which in fact demonstrates that the search for theoretical perfection does not always result in an invention which is at the same time practical and simple.

The cupola (*Figs. 11 and 12*) was designed for the use of raw coal, on the principle of the Duméry hearth (Paris, 1856), still in use for many purposes; in this construction the gas, after traversing the raw coal, is directed in a state of ignition upon the metal to be melted.

The Daelen apparatus is in reality a combination of a coke oven provided with a blast, a cupola and a reverberatory furnace, for the utilization of the waste heat of the cupola.

The raw coal is first coked in the chamber *a*, and the coke produced is pushed into the cupola *c*, until it is filled to the level *m*, and as the chamber *a* is emptied we continue the charging of raw coal by the hopper *t*.

As soon as the iron, which has been placed upon the hearth of the reverberatory furnace, becomes red, it is pushed directly into the cupola.

This cumbersome and costly apparatus appears to be without utility, and it is not to be supposed that it would have given very satisfactory results.

III.

THE INFLUENCE OF THE FORM OF THEIR VERTICAL SECTION ON THE WORKING OF CUPOLAS.

Some metallurgists have ignored the idea of utilizing the waste gas, and have confined their researches to the influence of the profile of the cupola; supposing that in this furnace, the form of the shaft, and the relations of sections at different levels, have an influence similar to that known to exist in the blast furnace.

Gerhardi and Ireland's Cupola.—A cupola built in 1863 at the foundry of Herr Borsig, in Berlin, by an English engineer,

* *Dingler's Polyt. Journal*, 1866.

is described by M. R. Gerhardt,* after it was perfected by him, was based solely upon the difference of its sections. This cupola was not, in fact, different from Ireland's. Gerhardt rejected, on principle, the cylindrical shaft, and his

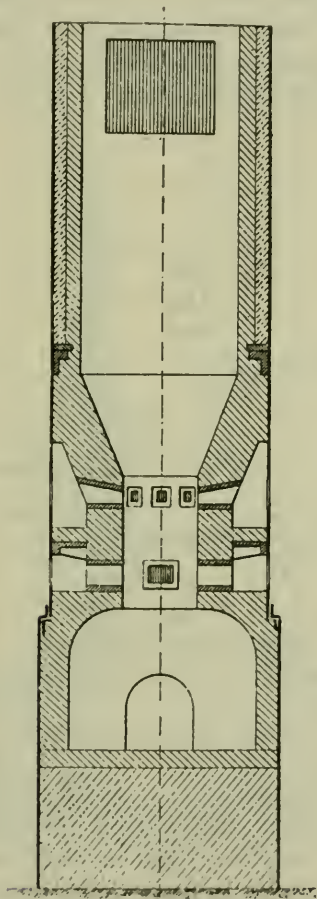


FIG. 13. The Gerhardt Cupola.

cupola comprised four distinct zones (*Fig. 13*), viz: the crucible, the zone of tuyeres, the boshes, and the shaft. The interior was lined with fire-brick, carefully shaped to avoid change of profile, especially in the vicinity of the tuyeres, of

* *Zeitschrift des Vereins Deutscher Ingenieure*, 1869. Vol. 13, p. 273.

which there was twelve arranged in two levels, the four lower tuyeres having a section twenty-five square inches (five inches square), and the eight upper tuyeres seven square inches (2'64) each. In order to repair with ease those parts adjoining the tuyeres and boshes (which are exposed to great wear, from the heat developed at these points), without removing the brickwork of the shaft, it is supported upon angle irons attached to the iron shell enveloping it.

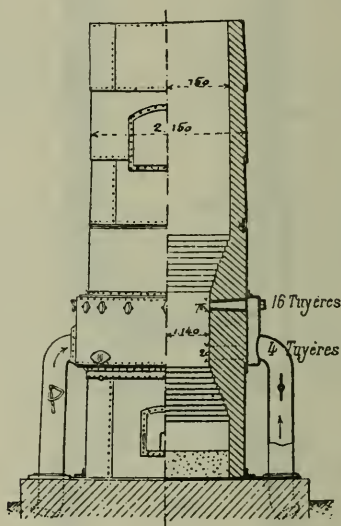
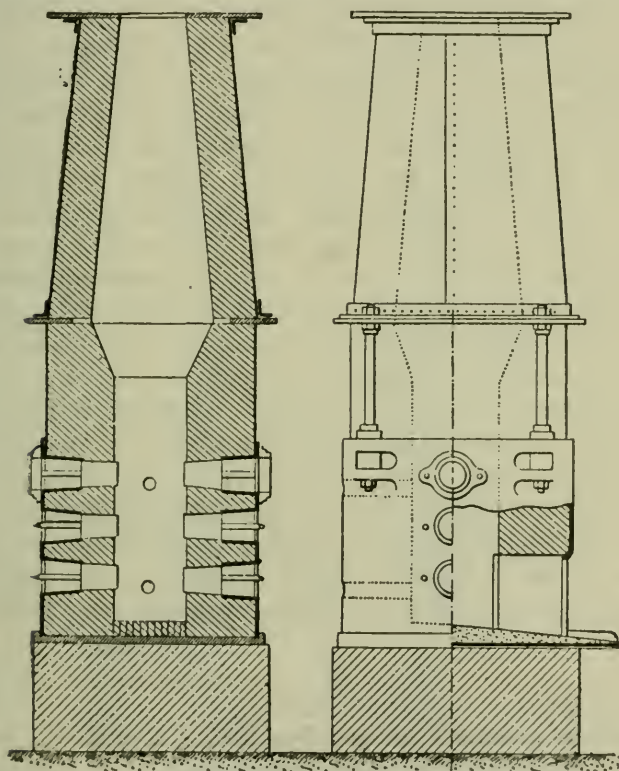


FIG. 14. The Ireland Cupola.

A cupola of this kind has a crucible thirty-six inches in diameter, and is blown with a wind pressure of from fifteen to sixteen inches of water, and melts from 4,959 to 5,730 pounds of iron per hour, with a total consumption of 13'5 per cent. of coke. A saving is made in the fuel required for "the bed" by not filling the furnace to the boshes, but only to the narrow part at the top of the crucible, the regular charge of 551 pounds of iron and fifty-five pounds of coke being immediately added. The blast is not turned on to the small tuyeres (the upper row) until the liquid iron is seen through the lower tuyeres.

The advantage presented by the narrowing at the tuyeres is, that we obtain by this construction a reduction of the volume of the charge, and ensure its regular descent at this point.

As the principal part of the combustion is concentrated at the smallest section, the temperature developed in front



FIGS. 15, 16. Cupola of the Naval Foundry of St. Gervais.

of the tuyeres is more elevated than in cupolas that are cylindrical throughout their whole height. The enlargement of the crucible is intended to collect a very large quantity of fluid iron at one time, in case it is required for the casting of large pieces.

Fig. 14 represents a cupola built by M. Ireland, at Bolton, in England, for the casting of an anvil block weighing 210 tons, and it has a section nearly identical with that of the

cupola just described, but its two rows of tuyeres are different in dimensions and number.

The first cupola built by M. Ireland had but two tuyeres, but in his later constructions he adopted sixteen and twenty tuyeres arranged in two rows.

Cupolas of St. Gervais and Nevers.—We will also speak of the cupola erected at the Naval Foundry at Saint Gervais in 1856,* in which the zone of fusion was very much smaller than the parts above it (*Figs. 15 and 16*). The lower part of the crucible was surrounded by a casing of cast iron, but its upper part, together with the boshes, was formed of fire-brick or moulded sand without a casing, in order that repairs could be easily made; the shaft was made of fire-brick enveloped with sheet iron, and rested upon four columns, by which it could be raised or lowered independent of the lower part, to compensate for the rapid cooling of the masonry of the boshes. This cupola had three rows of tuyeres, which were opened in proportion to the accumulation of melted metal in the crucible. The charge for lighting ("bed") was from 330 to 550 pounds of first quality hard coke; the pressure of blast was from six to seven inches of water, and the iron melted from 2,645 to 3,406 pounds per hour. The consumption of coke at Saint Gervais and at Nevers, where a similar cupola was built, was relatively low and indicated at that time an important progress.

	<i>Coke for Fusion, Per Cent.</i>	<i>Total Coke, Per Cent.</i>
Cupola No. 1, at Saint Gervais, first trial, . . .	6·08	10·29
Cupola No. 1, at Saint Gervais, second trial, . . .	6·45	10·32
Cupola No. 1, at Nevers, ...	?	11·28

The loss of iron was not four cent.

The same system applied to a cupola of very small dimensions mounted on wheels (portable furnace) gave a consumption of coke of 13·48 per cent.

Cooling of the walls.—In order to preserve the walls of the cupolas above the tuyeres from wear, a current of water is employed in a manner similar to its use for that purpose in blast furnaces.

* *Industrie Minérale*, 1858-59. Vol. 4, p. 59.

Cupola at Troy.—A cupola provided with a circulation of water around its boshes, built at the Albany and Rensselaer Iron and Steel Works, at Troy, N. Y., for the melting of Bessemer iron, and which is remarkable besides for its dimensions, is represented by *Fig. 17*. This cupola* is charged with a mixture of sixty-five per cent. of hard anthracite, and

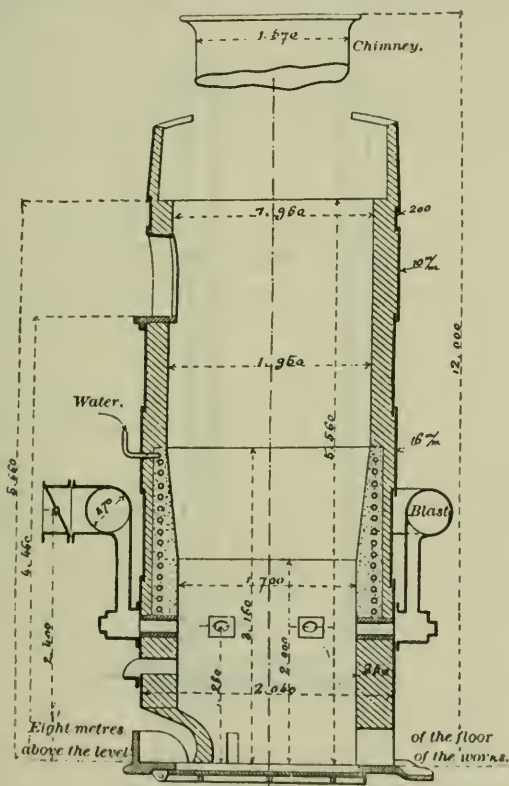


FIG. 17. American Cupola.

thirty-five per cent. of coke, and is provided with eight tuyeres, 5 x 8 inches. Except the boshes (which are rammed up of refractory material) the cupola is cylindrical; it melts at the rate of ten tons per hour.

The Gmelin Cupola.—Cooling has also been employed in cupolas whose sections are perfectly cylindrical; the cupola

* *Engineering*, 1880. Vol. 30, p. 592.

invented by M. O. Gmelin, of Budapest, and erected in the works of Ganz & Co. (manufacturers of cast-iron car wheels), is constructed with a double envelope of plate iron, in which the cold water circulates; there is no brickwork used except for the crucible; but a refractory plaster, one to two inches in thickness, is spread over the whole of the interior of the iron plating.

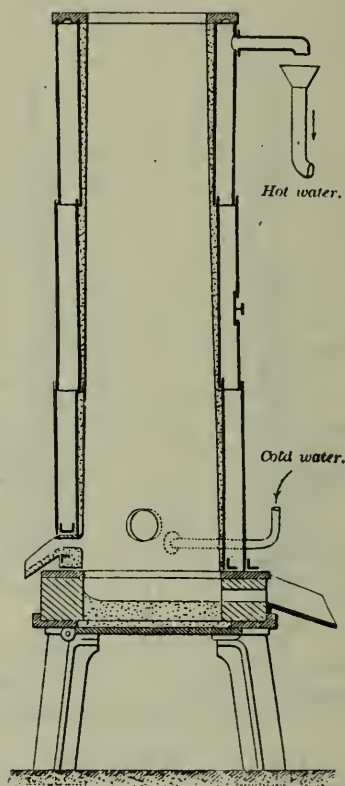


FIG. 18. The Gmelin Cupola.

When we consider that the heat given off to the water circulating in the hollow shell is at least fifteen per cent. of that developed in the furnace, and that this is about three times the heat which would be lost by radiation in case the shaft was constructed of masonry; it is evident that this design does not present an economy either in first cost, or

in maintenance. With such a cupola thirteen feet in height, and thirty-four inches in diameter, having an air pressure of from fourteen to sixteen inches of water, there can be melted from 10,000 to 11,000 pounds of metal per hour; the consumption of water being thirty-five gallons per minute. The advantages of this form of cupola are, the ability to secure a high temperature, obtain the iron hot, and the melting rapid, without fear of injury to the walls, and without inconveniently increasing the charge of limestone; lastly the temperature is constant at different heights.

IV.

EQUAL DISTRIBUTION OF THE BLAST.

The idea has been frequently advanced, that the regular descent of the charge in a cupola is an important condition of success; this idea is derived from the theory of the blast furnace.

The advantages of a regular descent of the material in a cupola are embraced in the facts, that all the coke is completely consumed; the iron melts at a uniform rate, and its composition is less liable to be modified by oxidizing gases, and therefore there is less waste of metal. In order to secure these results, it is necessary to obtain throughout the cupola as uniform distribution of the blast as possible. With the earlier constructions, having one or two tuyeres, this evidently could not be attained.

Now, let us consider the effect of two opposite tuyeres in a cupola.

The blast is introduced at a certain pressure, and, encountering the materials of the charge, is deflected into oblique currents, which reunite above the axis of the tuyeres; the combustion is active along the course of these currents, and the greatest heat is developed at *a*, where they unite, but at the same time at *b* the temperature is very low, which may be easily ascertained by introducing a bar of iron through the tuyeres *t, t*, and quickly withdrawing it.

Should we endeavor to obviate this inconvenience by disposing the axis of the tuyeres obliquely relative to the line *c d*, with a view of giving the blast a gyratory movement,

in which case the zone of combustion *a* is increased in diameter, but the low temperature at *b* still exists, or is somewhat increased by giving the axis of the tuyeres an inclination upward and downward, and by having a pressure

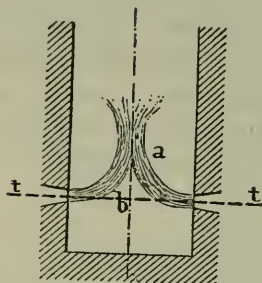


FIG. a.

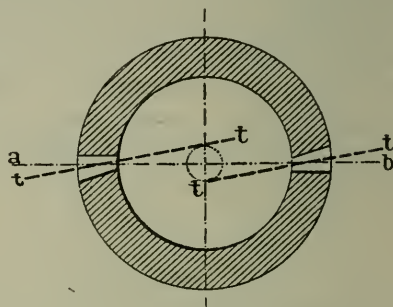
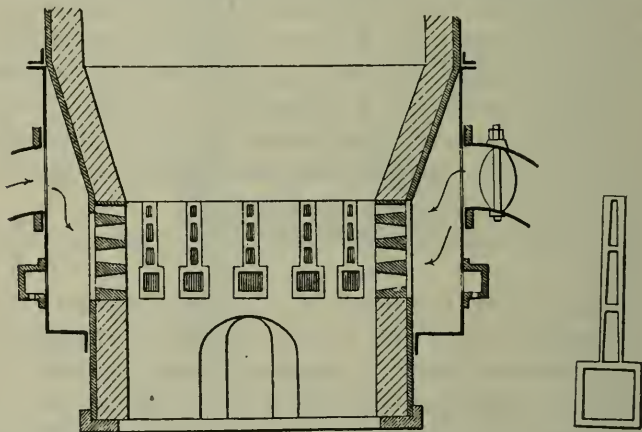


FIG. b.

of blast sufficient to overcome the resistance of the charge, which is only substituting this for the other inconveniences.

The Lawrence Tuyere.—An interesting arrangement, when considered with reference to the principle underlying it, is



FIGS. 19, 20. The Lawrence Tuyeres.

employed by M. Lawrence, of Philadelphia.* Immediately above the principal tuyeres, which are of rectangular section, there are three rows of orifices, each row being nar-

* *Polytechnic Review*, 1877.

rower than the one below it (*Figs. 19 and 20*); the jet of blast from the lower tuyeres is stronger, and is thrown farther into the interior of the cupola, than the jets superposed, which furnish the blast for that portion of the coke which lies near the walls of the shaft.

These tuyeres are placed around the circumference of the cupola at a distance of four inches from centre to centre.

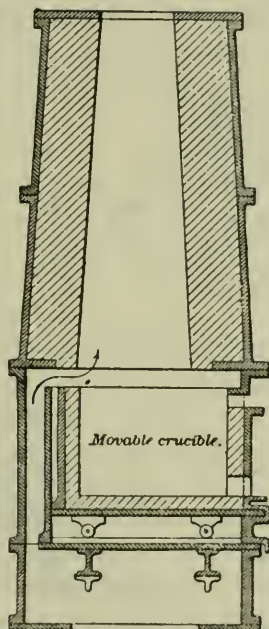


FIG. 21. The Bocard Cupola. Scale, 1-40.

The Bocard Cupola.—The best system that has been proposed for the purpose of ensuring an equal distribution of the blast, is that which introduces the air around the whole circumference of the cupola, by means of a continuous slit.

The *Genie Industriel* described, in 1858,* a cupola based upon this principle, which was invented by M. Bocard, of Chatillon sur Seine (*Fig. 21*). The level of the introduction of the blast in this system was necessarily fixed, and could not be vertically displaced. This cupola was pro-

* Armengaud: *Genie Industriel*. Juillet, 1858, p. 9.

vided with a crucible of large dimensions, mounted on wheels, which enabled it to be readily removed and replaced, and also allowed it to be used as a casting ladle. In a cupola of this construction, having a section of sixteen inches square, it is said that from 3,300 to 4,400 pounds of iron were melted per hour.

Some years later MacKenzie secured a patent for an arrangement for introducing the blast by an annular slit. Afterwards, in 1880, came the cupola of Fauler, of Freiburg

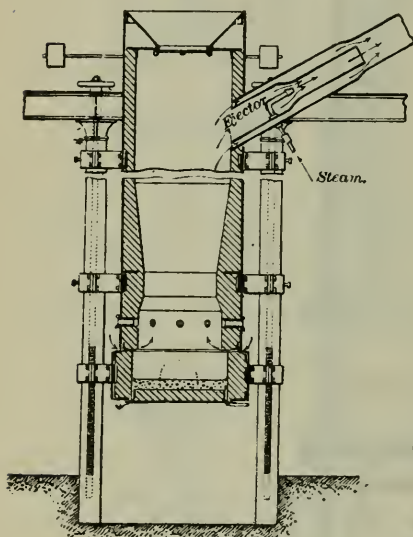


FIG. 23. The Herbertz Cupola.

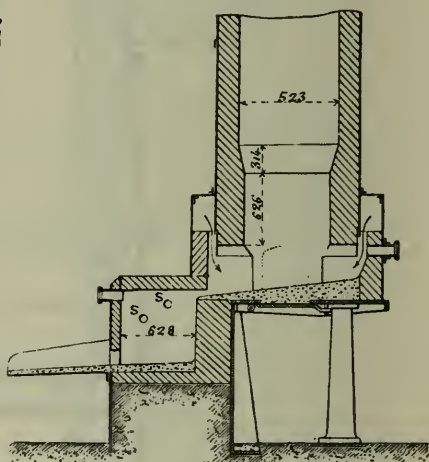


FIG. 26. The Common Krigar Cupola.

(Baden), in which a hollow ring of cast iron, having a slit, distributed the blast throughout the whole circumference of the cupola.

Still these arrangements did not allow, except with difficulty, the inspection and cleaning of the annular conduit of the blast in case of an overflow of slag, and these conduits wore out rapidly, and were often difficult to replace.

Krigar's Cupola.—The cupola constructed by M. Krigar, of Hanover, and which is employed in a large number of works in Germany, also ensures a regular distribution of the air by means of an annular box (*Fig. 26*) having vertical

rectangular orifices, which open immediately into the largest part of the crucible proper, and as the blast is compelled to rise in the charge by passing through the narrowed section directly above the orifices, they are never affected by the slag, and all the melted iron is collected in a separate crucible placed in front of the cupola.

The total consumption of coke in a cupola of this kind is from 10·4 to 15·7 per cent. of the iron charged. Nevertheless, this apparatus, like all the preceding, presents the inconvenience that the quantity of air blown in at a constant pressure is invariable, unless dampers are used to control its admission.

This is not the case in the *Herbertz* system, which also employs an annular tuyere, but which is capable of adjustment as the height of the iron varies, and at the same time by employing the method of aspiration, the lower part of the cupola is entirely free from trouble arising from the stoppage of the tuyeres.

However, notwithstanding that the *Herbertz* system of annular tuyere is intended to secure an equal distribution of the wind throughout the section, the employment of a jet of steam in the upper part of the cupola for creating a draft produces a contrary effect; in other words, the gas is made to traverse the charge through its largest interstices, and the greater part escapes without being utilized, thus producing an irregular combustion. The published analysis of the gas from this cupola shows an excessive amount of oxygen, which indicates the presence of large spaces in the charge.

(*To be continued.*)

FEASIBILITY OF UNDERGROUND RAILROADS IN
PHILADELPHIA.

BY LEWIS M. HAUPT.

[*A Lecture delivered before the FRANKLIN INSTITUTE, Monday, November 5, 1888.*]

Prof. HAUPT was introduced by the Secretary of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

As in the physical world, there is "first the blade, then the ear, and then the full corn in the ear," so in the material world there is a gradual development extending over a longer or shorter period of time.

The philosophic poet, Shakespeare, divides the life of man into a number of distinct stages, and the observant philosopher will find corresponding phases in the materialization of every idea. But that an idea may germinate successfully and bear fruit, its time, place and conditions must be favorable. It must be in season. If ahead of or behind the times it will not mature; but the test can only be made by exposing the idea to the intelligence of the community. If ripe, it will be accepted; if not, it must lie fallow.

It will require no effort of the imagination to discern the several stages in the development of the subject suggested for this lecture.

In the evolution of a material project, the first stage is that of mental conception; the second, that of education and propagation; and the third, that of execution or fruition. The first step, concerns merely the one or more individuals who may have planned the project; the second, concerns the community, or those in whose behalf the works may have been designed. It is the crucial stage, as it involves the very existence of the plan. This question is then submitted to those interested. Will you or will you not accept this work, in its existing or in any modified form,

upon any given or required condition? This is the present phase of the rapid transit problem in this city. To answer it intelligently, it is necessary that the project shall be fairly presented to, and be understood by the community; that it may decide without bias, and with a view to promote the best interests of the municipality as a whole.

To aid in disseminating knowledge as to these important commercial, social and engineering problems, is one of the purposes of this course of lectures, given under the auspices of the FRANKLIN INSTITUTE, and hence I shall confine myself to-night to that part of the second stage, which treats of the physical possibilities and characteristics of the project, to give Philadelphia rapid transit by underground roads.

Your first interrogatory will naturally be, Is it practicable? In answering it, we must consider the requirements of the proposed way, and size of the rolling stock, to determine the proper dimensions; and then apply these to the topography of the site, with its numerous obstructions, to discover whether it is possible to construct such a conduit. The next step, will be one of cost and expediency; this has already been partially considered on a previous occasion. To be successful, and to relieve the surface of the frequent and dangerous grade crossings, it is necessary that the tunnels should be large enough to pass the existing rolling stock on the steam roads entering the city. This requires at least 15 feet in height and $10\frac{1}{2}$ feet in width, for a train of maximum section, so that for a double-track tunnel, with allowance for clearance, the neat section must be about 17 x 25 feet. For pavement over the crown of the arch, about three feet would be required, thus bringing the grade of the tunnel twenty feet below that of the surface. We now have the two elements of width and depth necessary to provide a passage-way and, wherever these can be obtained on a continuous line, there the road could be constructed. It has been objected that this is but a small part of the problem, but it is the vital part, and, if this be possible, it cannot be said that the project is impracticable, however inexpedient it may seem.

To ascertain whether or not this continuous line may be obtained, it is also necessary to know the practical limits of the changes in direction (both vertically and horizontally) of modern rolling stock. For these data we may take the maximum resistances found on existing lines of railways; thus, on the P. W. and B. R. R. approach to the tunnel under Thirty-second Street, there is an ascent of 1·2 feet per hundred on a curve of 12° , or radius of only 478 feet, while the maximum limit of curvature on a level, for a road locomotive, with ordinary wheel base is 19° . On the Schuylkill Valley Division of the P. R. R., near West Laurel Hill, there are grades of 2·3 per cent. or 121·4 feet to the mile, and on the Reading R. R. there are grades of 2·5 per cent.

On the Manhattan Elevated R. R. of New York, the sharpest curves have a radius of only ninety feet.

We have just seen that the level of the underground roadway should be at least twenty feet below the surface. To ascend from that depth with a two per cent. grade, the ground being level, would therefore require a length of one thousand feet, and to rise still higher, so as to make an overhead crossing, with a minimum clearance of thirteen feet and three feet for superstructure, would take 800 feet more, or from underground to overhead a total of 1800 feet; the surface being level. Hence, it is freely asserted that it is impossible to connect the present surface terminals with an underground system. But it should be observed that this distance diminishes as the surface slopes increase, until it reaches zero, when the inclination is vertical—as at the face of a tunnel or retaining wall. By studying, therefore, the topographical features of the site, the physical possibility of the project may be determined.

At this time, when the subject of greater facilities is attracting so much attention, it becomes a matter of great importance to examine both sides of the discussion, that correct conclusions may be reached. This can best be done by taking the opinions of competent engineers who are opposed to underground roads, as being antagonistic to other projects which are believed by them to offer a more acceptable solution. If there are insuperable physical difficulties in

the way, there should be no better authorities to discover and proclaim them than these engineers.

Hence I assume that in devoting a short time to the consideration of these public objections, I will best reply to the doubts which may exist in the minds of those most interested in the subject.

The first objection, as stated, is to the effect that :

"Philadelphia, * * * south of Lehigh Avenue, is not topographically suited for an underground scheme. * * * The area of Philadelphia in question is nearly level (excepting at the rivers), and the subsoil, with its beds of clay and underlying quicksands is bad enough in which to obtain foundations for ordinary work, without trying to build an underground conduit which cannot be drained." *

In this comprehensive quotation objections are raised on the score not only of the topography, but also of the geology, construction and drainage. But they are not specific, unless it be in the statement that "Philadelphia is nearly level." The elevation of the plateau is not stated, but it will be seen that the objection is inapplicable when it is remembered that ordinarily level country is that best adapted for railroad construction and operation. For underground roads it is particularly favorable, because of the light grades it affords. It is only necessary that the plateau be sufficiently elevated to permit the conduit to be placed between wind and water, or about twenty feet above datum, to remove most of those objections. It will be interesting to examine the site of the city denuded of its present structures, or as it appeared to the topographical engineers of Lord Howe's army of occupation in 1777-8. For this purpose I refer to the excellent map of that date, published in London in 1779. Although this chart gives no elevations, it shows the surface drainage, hills and ravines in relief and thus indicates the approximate position of the divides, which are the controlling lines in a project of this kind. A well-defined ravine is found extending across the northern

* See p. 22, Pamphlet entitled, *The Philadelphia and Reading Terminal* R. R. Dunlap & Clark, 819 Filbert St., Phila.

limits of the old city formed by the bed of Pegg's Run, or Cohoquinoque, and the southern slopes of Bush Hill and Fairmount.* This formed the line of defence of Lord Howe, who dammed the mouth of the creek and flooded the meadows for some distance. At a later date, 1796, it was the site of the canal partially built and intended to connect the two rivers. And still later it became the bed of the Philadelphia and Reading R. R., the creek having been encased in the sewer now underlying the roadway on Willow Street.

Concerning this locality, Watson says: "No part of Philadelphia has undergone such great changes as the commons bordering this run. At the north end the high table-land of the city terminated in a high precipitous bluff, at about 250 feet north of Callowhill Street. This extended from Front Street, at Pool's Bridge, up as high as Fifth and Sixth Streets, bounding the margin of Pegg's Run. On the north side of this whole range, there was an extensive marsh into which the Delaware flowed. Beyond this marsh was a high, open common. * * * The descent of Second Street, from Callowhill to the stone bridge, was nearly as great as at Race and Front Streets now. * * * In that time the short street (Margaretta), south of the bridge, did not exist, but the brick house, which forms the south side corner house, was the utmost verge of the ancient bluff. From Third to Sixth Streets, on the south side of Pegg's Run, being very high, furnished all the gravel used in the city end of the Germantown turnpike." It has been stated that at an earlier geological period the Schuylkill River crossed the peninsula through this ravine, converting the site of the city into an island. Thus it is seen that the Pegg's Run hollow (now Willow Street) has played an important part in the history of the city, both for transportation and defence, and that the topography is peculiarly favorable to the construction of an underground line, furnishing an easy and short transit to the surface at the east end.

* The Secretary, Dr. WAHL, has prepared a slide from a rare and valuable atlas belonging to the library of the INSTITUTE.

As the north and west branches of the Reading system meet here on tide-water, it formed a natural point for transshipment, and hence an extensive terminus was constructed. Concerning this, it is pertinently asked by a prominent engineer: "Supposing a subway was made, how could connections be had with the company's freight yards on Pennsylvania Avenue and at Willow Street wharf, etc., and if the depressed road is to come to the surface at the wharf, what is to be done with the north and south streets that will be cut off? * * * Perhaps the advocates of the underground plan can answer these questions, but I cannot."

The answer to the query will be seen in the profile. Callowhill Street, from New Market west, lies above the twenty-two foot plane, and the former bluff at Margaretta Street enables a line to be built connecting the surface tracks on Delaware Avenue with the tunnel under Callowhill, without a grade crossing, by merely changing slightly the elevation of a short back street. It is a very simple and comparatively inexpensive case. As to the injury to the company from loss of patrons, it would not be serious, as they would still adhere to the company and move the coal-yards to the new location, while the company would be saved the annoyance, delays and expenses resulting from grade crossings, whereby an occasional life is sacrificed and a bill for damages is rendered. To determine the actual extent of this patronage between the Delaware River and Broad Street, where it would be necessary to shift the location slightly to the south, I made a *reconnaissance* of the route and found a total of only eighteen establishments having sidings connecting them with the line. Of these, eleven were coal-yards and the balance miscellaneous business. Out of the eight sidings on the south side, six led into coal-yards, and most of these extending through to Callowhill Street could be served as well from the subway under that thoroughfare. As a coal-yard is always on the move, it would seem to be a very simple matter to change its location slightly without great detriment to the business.

Upon a critical examination of the topography with reference to the proposed location, we find these objections

vanish, as there is no point where the difficulties cannot be overcome by well known expedients. Similar objections would have applied with much greater force to the Metropolitan Railway of London, and yet even there they have been successfully solved.

With reference to the geology, it may be said that the character of the subsoil can only be certainly known by numerous borings or by actual work in it, and that the statements concerning the beds of clay and underlying quicksands must be taken with large allowance. Doubtless there are spots or pockets of this description, but as a rule the material is well adapted for foundations and easily excavated. Prof. Hall, geologist, says: "The entire northern portion of Philadelphia County is covered by gravel, a greater portion of the south end of the city of Philadelphia is covered by mud. Flanking these deposits, a belt of Trenton gravel extends along the course of the river. This was deposited by the river before it had receded to its present channel. These gravels merge into the brick clays, red gravel and yellow gravel very variable in thickness. Through the southern portion of Philadelphia it is not far from one hundred feet in depth. There are exposures of this gravel in all sections of the city where streets have been graded down."

It would seem then that gravel would be the predominating material, and as this is easily worked, drains itself, forms a good foundation and has a commercial value, it ought to reduce the cost of such a work and prove an important adjunct.

The objections to drainage are met by a reference to the London experience, where the southern portion of the "Inner circle" traverses the old bed of the river and the swamps of Pimlico and Bridge Creeks. "As a matter of fact the average rail-level is thirteen feet below Thames high-water," and the District company operates five pumping stations between Kensington and Blackfriars. At Charing Cross the walls of the covered way had to be carried to a depth of thirty-seven feet below high-water, to secure a solid foundation, as this part of London is built largely on made ground and silt.

In the profiles suggested for Philadelphia, there are but two points where the grade falls a few feet below high-water. These are on Market Street, at Fourth and on South Broad at its intersection with Morris, where, if a large amount of water were encountered, pumps might be required, but by suitable constructions it is expected to avoid this expense,

Several other specific objections are made, but they are more imaginary than real, and time is wanting for their consideration. We may find it important, however, to review briefly the summary of the reasons for regarding the subway projects as impracticable. These are as follows: It is said that, "the road on Broad and Market Streets never should be accepted by the Reading Company for the following reasons:

(1) "Because it would be in the highest degree objectionable for the Reading Company to transfer all its business at Germantown Junction to another railroad owned by other persons."

The answer to this is that, if the Broad Street tunnel is to be owned and operated by a company hostile to the interests of the Reading R. R. and the city, then the objection is well founded, and it would be folly for the management of that road to undertake such an entrance; but it is entirely feasible for the Reading system to own, construct and control an independent tunnel from its lines on North Broad Street to Twelfth and Market, for, I believe, less money than the cost of the present route with its expensive right of way and damages. The plans for this project will be shown subsequently. Under these conditions the first objection would not be valid.

(2) "Because of the extreme cost of the proposed subway and of the necessary terminal facilities connected therewith."

For the municipal travel it is not necessary that the terminus should be under the surface. It may be placed wherever property is cheapest and supplies may be most readily obtained. Stations will cost but little and may be made a source of revenue. So, for a trunk line, it is injudi-

cious to seek for room underground for storage of engines, cars, fuel, water, repair-shops and general supplies. It is sufficient if there be space for the making up of trains and the handling of the traffic, and there is no difficulty in providing the required space for these purposes.

Now, as to the "extreme cost," perhaps a comparison can best be made by taking the estimate of the proposed Reading terminal from Glenwood Avenue to Ninth and Willow, and from Thirteenth Street, on Pennsylvania Avenue, to the Delaware River, as published under date of May 8th last, as a basis.

For this distance, which by the city map is found to be about 20,000 feet, it is stated that the approximate cost of an elevated railroad to replace the present surface tracks as they exist to-day, * * * including the construction of freight and passenger stations, etc., to give the railroad company facilities equivalent to what they now have, would cost \$12,750,000. "This cost is exclusive of any property that might have to be purchased for yard purposes, and does not take into account the construction of an elevated road from Willow Street to Market Street." Thus, the cost of an elevated structure with stations, but exclusive of right of way, property, and damages, is found to be about \$638 per lineal foot or \$3,368,640 per mile.

In comparison with these figures, let us take the cost of actual tunnel work similar to that proposed. The Fourth Avenue Improvement is four and a half miles in length, and of this distance, 10,662 feet are in tunnel, and the balance viaduct and subway. There are four tracks occupying a cross section seventy-six feet in width, at some places, yet the cost per lineal foot was but \$285 or \$1,504-800 per mile, which is only forty-four per cent. of the above estimate for the elevated road without damages. This single instance should suffice to answer the second objection.

(3) "*Because of the impossibility of satisfactorily operating the subway.*"

Again, we may refer to actual precedents in reply to this statement. On the Philadelphia and Reading systems it is

asserted that there are about 200 trains passing over the crossings at Ninth and Green Streets. On the Connecting R. R. and Kensington Branch of the Penna. R. R. there are 174 trains daily. This would aggregate say 400 trains on both lines for a four track road (both ways) or 100 trains per track. On the Third Avenue elevated railway of New York, there are 490 trains going north and the same number coming south each day, or about five times the number of trains as are now running on the combined steam surface roads of this city, and their terminals are greatly contracted, being in the air.

(4) "*Because the subway plan cannot be adapted to the other lines of road operated by the Reading Company in Philadelphia.*"

An examination of the profiles will show how readily the proposed lines may be made to connect the Reading Station at Broad Street with the underground line on Pennsylvania Avenue and Callowhill Street, extending from the B. and O. tunnel to Delaware Avenue, and also with the P. G. and N. and North Penn or Bound Brook lines, making a complete connection and dispensing with a large number of grade crossings.*

(5) "*Because it would be unwholesome and unsatisfactory to the public.*"

The first part of this objection is doubtless supposed to result from improper ventilation, smoke, gases and darkness, a condition of affairs more or less imaginary, yet met, in part, by the antiquated precedent of the Metropolitan and District Underground Railway Companies, of London, which own and operate over forty-three miles of completed lines.

So also in numerous existing tunnels, unprovided as they are with any aids to ventilation, we find no injury to the travelling public from these or other causes, although their lengths greatly exceed those of the subways proposed here. Thus the Hoosac tunnel is very nearly five miles long, the

* The extensive profiles and plans accompanying this lecture, are not reproduced for manifest reasons.

Mt. Ceniz about eight, and the St. Gothard over nine; without producing any complaints as to their unwholesome or unsatisfactory condition. In the lines proposed here from Twelfth and Market Streets to Glenwood Avenue, the length would be a little over three miles, with at least as many openings for ventilation, and on the Pennsylvania Avenue or Market Street divisions it is but a little more than two miles across the city. Moreover, engines can be made to retain their smoke for long distances, and in most cases the grades would be light, being within one-half of one per cent. or half of a foot per hundred, so that the anticipated evils of the underground way would doubtless be found to be imaginary. In a city like London, where the poor cannot well ride in cars, and the rich do not, to any great extent, the fact that 40,000,000 of people were carried on the underground roads during the first six months of this year, would seem to indicate that this mode of travel is not so unsatisfactory as to preclude its use. It should also be observed that the ratio of travel to population is generally much less in continental than in American cities. In London, for example, it is about seventy-seven to one for all lines, while in New York and Philadelphia it is about 125 to one for surface travel only.

The next objection as stated is :

(6) "Because it would forever preclude the growth of business on the lines of the Reading Company, and prevent any extensions in the future to meet increased business. The four tracks proposed on Broad Street would be fully occupied at once by the business of the Reading Company, and as the whole width of the street would be taken up, no more tracks could be provided in the future." * * "As for running both the Reading and Pennsylvania trains through the tunnel, that would be a physical impossibility, for there would not be room enough."

The answer to these statements has already been given.

The seventh and last of this group of objections is to the effect that, "The destruction of the Reading Railroad terminal facilities in Philadelphia would entail a loss on the city and its inhabitants impossible to estimate."

Such a result would doubtless prove to be a great calamity, but from what has already been presented in reply to the above arguments, it would appear that no such effect would follow the construction of the contemplated lines. On the contrary, they would serve as links to bind together more closely the now disjointed termini of this great railroad system, and thus greatly increase its facilities for expanding and handling its augmented business, while it would relieve the surface of a large number of dangerous crossings.

This review of these objections has necessarily been very brief, but if the answers are satisfactory they should go far towards preparing the way for the entrance upon the third stage of this important municipal development, viz: that of construction.

This leads us to the consideration of the peculiar physical difficulties which have, by some persons, been declared insuperable.

They partake of the nature of special problems, and are to be found at those points along the line where obstructions are encountered, involving a change of grade or of direction. Thus the necessity of passing underground from the surface at the foot of Market and of Willow Streets; of making the circuit of the Public Buildings; of rising from under west Market Street to cross the Schuylkill River and the Junction Railroad, and of reëntering the ground without crossing a street at grade; of providing independent lines for the business of the Reading and Pennsylvania Companies, and passing one over the other without a grade crossing; of connecting the branches of the Reading system by an underground line and not destroying its patronage; of connecting the northern and eastern traffic on both lines with their respective tunnels under Broad Street, thus greatly reducing the time and distance for local travel; of passing out from South Broad Street to the surface, and providing ready access to League Island, Girard Point, Point Breeze and other remote localities; also, of providing for the proper drainage, lighting and ventilation of the subway without destroying the city service or sewerage, and at

the same time providing for the large amount of local traffic which such an enterprise would develop.

These are some of the features of the general problem. The more important ones, and especially those declared to be impracticable by the advocates of other projects, have been carefully considered and satisfactorily solved.

[NOTE.—These solutions were explained by reference to the profiles.]

Thus it will be seen that these supposed impossibilities are all brought within the range of practicable limits, and so far as appearances indicate, the difficulties are of a much simpler character than those encountered in the London prototype.

Upon inquiry, and from personal examinations of a large number of deep foundations, and from the experience of well-diggers, I find that there is very little true quicksand to be met with within the limits of the required depth; that standing water is generally more than twenty-five feet below street grade; in some places it is over forty, and east of Second Street, on Market, it is believed to be even lower.*

The material generally is loam, clay and sand, underlaid with compact gravel, which gives an excellent foundation. In some instances, as on North Broad and West Market Streets, soft rock may be expected. In fine, the physical conditions are found to be unusually favorable.

But there is another class of objections arising from the financial considerations, and it is necessary to show that the probable revenues will pay a fair dividend upon the investment. This question was considered in my lecture before the INSTITUTE last November, but for the benefit of those who may not have access to the figures, I will state that the Fourth Avenue Improvement in New York, built only for use by steam railroads, and already referred to, cost at the rate of \$1,504,800 per mile. About one-half of this is in tunnel, and the rest in viaduct or open cut work, which was almost if not quite as expensive.

* Col. C. E. Livingston, whose large experience with "driven wells," makes him an authority on this subject.

The Union Tunnel under the streets of Baltimore, built in 1871-73, twenty-six feet wide, double track, cost \$247 per lineal foot or \$1,304,160 per mile.

The Metropolitan Railway, of London, which ran under private property, and encountered many exceptional difficulties, cost \$56,645,420, or about \$2,360,000 per mile; of this amount more than half was for real estate, yet this company is now paying dividends of two and three-quarter per cent. on the ordinary stock and two and one-half on the surplus land stock.

The Berlin Elevated Railroad is reported to have cost \$2,115,000 per mile, including the right of way. The Pennsylvania Railroad Company's Elevated Road on Filbert Street, in this city, cost at the rate of \$1,604,480 per mile, whilst the Reading Company's estimate for elevating their tracks was at the rate of over \$3,000,000 per mile, and the Manhattan Elevated Company, of New York, is capitalized at \$1,055,000, with little or no damages paid.

From these comparisons it would seem that under favorable conditions an underground system should cost less than one which is elevated and the expense of maintenance would undoubtedly be greatly reduced.

It is worthy of note, in connection with the statement recently made, that the London underground road did not pay, and if it had to be done over again it would not be built; that the city of Glasgow, having all the benefit of the London experience, is just about inaugurating a similar project, extending for seven miles through the heart of the city and penetrating clay, sand, gravel and rock, and in two places dipping below the level of ordinary spring tides. "The estimated cost of the road is \$5,655,000, of which \$1,135,000 is for lands. Adding ten per cent. for contingencies, it brings the cost per mile, for construction, to about \$885,000. The section is a double trackway about twenty-six feet in width.

As to the probable receipts, it has been shown that the local passenger traffic alone, in a city like Philadelphia, may safely be placed at three million per mile per annum, producing a revenue of over \$200,000, which would be the

interest at five per cent. of four millions. But the revenue could be largely augmented by rentals, and tariffs on freights which could be handled largely at night, so that there would appear to be sufficient income in sight to provide for a much larger expenditure than the estimated average cost of the work, which is placed at one and a half million dollars per mile.

It is worthy of remark that in reviewing the history of the London road Mr. Jno. Fowler writes: "After the contract was let and the works had been let on the first section of the line, great public and professional interest was felt in the undertaking, but at the same time it was considered to be an experiment. At the monthly board meetings of the directors, he was often told that members of the board had been warned by engineers that the line never could be made, and that even if made, it could never be worked, and even if worked, that no one would travel by it." He adds, "This was rather discouraging, but he had studied the work carefully, and believed in it, and the directors believed in him, and he did make it, did work it, and the public travelled by it." Thus, after the lapse of a quarter of a century, we find history repeating itself, and similar predictions of failure are freely made in this city to-day, but it will be observed that they come from parties who presume that their interests may be injuriously affected by the construction of the proposed lines.

Because attention has been directed in this lecture, particularly to the feasibility of underground roads, I do not wish to be misunderstood as opposing any project which may increase the velocity of travel, and it is an encouraging sign to find that the members of Councils are disposed to consider every earnest effort made with this end in view, whether elevated or depressed.

In conclusion let us look briefly at the benefits to be conferred by such an improvement.

(1) The city is intersected and girdled by steam railroads "at grade," giving at least 25,000 train-crossings per day. About 500,000 passengers ride in the horse and steam cars daily, and it is scarcely possible to go any moderate

distance without having to cross an intersection, causing delays and risks.

By the underground lines a very large amount of this local movement will be provided for, the risks will be reduced and the speed be greatly increased.

(2) The areas available for residence will be greatly extended in consequence of the increased velocity of travel. It has been shown heretofore that this area is proportional to the square of the velocity and that for pedestrians the practical limit to the area of Philadelphia is six and three-fourths square miles; for street car travel, at the rate of three miles per half hour, it is thirteen and one-half square miles; for elevated travel, at the rate of six miles per half hour, it is fifty square miles; while for underground travel, at the rate of ten miles per half hour, it is 147 square miles.

In 1858, when the first street car line was opened, the built up part of Philadelphia covered about seven square miles, or it had just passed the pedestrian limits, and its greatest length was a little over four miles along Fifth and Sixth Streets, where the first track was laid. In other words, it was a two mile, or thirty minute, walk to the outskirts from the centre.

About ten years ago the city passed the half-hour limit of travel in street cars, yet, if we except the cable lines, no relief has been provided, and the exodus by the steam roads has grown to such proportions that they are taxed to their utmost capacity to accommodate the travel.

Increased velocity, accompanied by greater safety, also means increased valuation to suburban property, and augmented revenues, without raising the tax rate.

(3) It is so common an event to have our principal streets broken up by the numerous applicants for underground privileges, that the business men would doubtless find it convenient to have portable bridges or skids to enable them to load teams beyond the trenches, were it not for the car tracks which occupy the middle portion of the streets. In fact this nuisance has been carried so far, that not long since a contractor was obliged to enjoin one of the city officers from tearing up his recently laid pavement to lay pipes, at

least for a long enough time to enable him to have it approved and get his warrant. With suitable subways it would be possible to lay respectable pavements in this city, and it would save a large annual expense for repairs, cleaning and maintenance. Our present pavements are not conducive either to health, morality or humanity.

(4) The drainage of the portion of the city through which the subways passed would be very much improved.

(5) The convenience of through as well as local passengers would be met by a quicker transit and a saving of several miles of distance by the circuitous lines across the city. In fact, by some lines there is no connection for through travel and passengers must be transferred at considerable inconvenience and some additional expense to reach their destination. This may be avoided by the proposed lines, which will connect the terminals of the various railroads directly with each other by the shortest lines.

Much more might be said upon this subject, but I will only add that under the favorable conditions existing here, and with the precedents of successful operations abroad, those who do not believe in the feasibility of an underground railroad in Philadelphia must have very little confidence in the possibilities of a profession which has done so much to make life not only endurable but absolutely enjoyable, and which has added so greatly to the wealth and rapid development, not only of this country but of the world.

Civil engineers justly may be said to be civilizers.

[The lecture was closed by an exhibition of lantern projections showing sections of the various underground railroads in existence, or proposed.]

INDETERMINATE MULTIPLIERS FOR THE CONTINUOUS GIRDER.

By C. H. LINDENBERGER, C. E.

Mr. Merriman's system of indeterminate multipliers for the continuous girder has long been recognized as the most convenient method of solving this problem. I propose in the following article to develop that theory into a formula by which any set of equations may be solved which have the form of the Three Moment Equations, in which the unknown terms correspond to the pier moments, but *all other terms are entirely arbitrary and may have any value whatever, either real or imaginary.* The problem will however be discussed as if it were a problem of obtaining pier moments.

Let M be any pier moment;

l be the length of a span;

s be the number of spans;

y be the arbitrary term at the end of the equations.

The quantities M , l , and y , are to be defined by a subscript denoting which one is meant. The " y " quantities include all terms denoting the state of loading and height of supports, and need not be further defined than to show where they appear in the "Three moment" equations.

These equations will then be :

$$\begin{aligned} 2 M_2 (l_1 + l_2) + M_3 l_2 - y_2 &= 0 \\ M_2 l_2 + 2 M_3 (l_2 + l_3) + M_4 l_3 - y_3 &= 0 \\ \&c. \qquad \qquad \&c. \qquad \qquad \&c. \qquad \&c. \qquad \&c. \qquad \&c. \end{aligned} \quad (1)$$

$$M_{s-2} l_{s-2} + 2 M_{s-1} (l_{s-2} + l_{s-1}) + M_s l_{s-1} - y_{s-1} = 0$$

$$M_{s-1} l_{s-1} + 2 M_s (l_{s-1} + l_s) - y_s = 0$$

There being $(s-1)$ equations.

Now suppose these equations multiplied by indeter-

minate multipliers, the first by D_2 , the second by D_3 , &c. &c., and the equations thus multiplied be added together, and arranged according to the moments, then we would have the following equation :

$$\left\{ \begin{array}{l} M_2 (2 D_2 (l_1 + l_2) + D_3 l_2) - D_2 y_2 \\ + M_3 (D_2 l_2 + 2 D_3 (l_2 + l_3) + D_4 l_3) - D_3 y_3 \\ + \text{\&c.} \quad \text{\&c.} \quad \text{\&c.} \quad \text{\&c.} \quad \text{\&c.} \quad \text{\&c.} \quad \text{\&c.} \\ + M_{s-1} (D_{s-2} l_{s-2} + 2 D_{s-1} (l_{s-2} + l_{s-1}) + \\ \quad \quad \quad + D_s l_{s-1}) - D_{s-1} y_{s-1} \\ + M_s (D_{s-1} l_{s-1} + 2 D_s (l_{s-1} + l_s)) - D_s y_s \end{array} \right\} = 0 \quad (2)$$

Now the problem is to find a set of multipliers so that *any pier moment at will*, that we may select, that we will designate by M_q , shall have the co-efficient Z_q , while at the same time the coefficients of all the other pier moments become $= 0$, so that we can write

$$M_q = \frac{D_2 y_2 + D_3 y_3 + \text{\&c.} + D_{s-1} y_{s-1} + D_s y_s}{Z_q} \quad (3)$$

and we must find a short and easy method of obtaining Z_q , and the value of each separate indeterminate multiplier and prove that the "Three Moment" equations are fully satisfied.

Assume the following set of equations :

$$\begin{array}{l} D_1 l_1 + 2 D_2 (l_1 + l_2) + D_3 l_2 = Z_2 \\ D_2 l_2 + 2 D_3 (l_2 + l_3) + D_4 l_3 = Z_3 \\ \text{\&c.} \quad \quad \quad \text{\&c.} \quad \quad \quad \text{\&c.} \quad \text{\&c.} \end{array} \quad (4)$$

$$D_{s-2} l_{s-2} + 2 D_{s-1} (l_{s-2} + l_{s-1}) + D_s l_{s-1} = Z_{s-1}$$

$$D_{s-1} l_{s-1} + 2 D_s (l_{s-1} + l_s) + D_{s+1} l_s = Z_s$$

There being also $(s-1)$ of these equations.

(1) Write c for D in these equations, assuming that $c_1 = 0$, $c_2 = 1$, and that $c_{s+1} l_s = -Z_s$, and substitute 0 for the Z^s on the right. These will be the c multipliers of Mr. Merriman.

(2) Write d for D in these equations, assuming that

$d_s = 1$, $d_{s+1} = 0$, and substitute 0 for the Z^s on the right, as before. These will be the d multipliers of Mr. Merriman, but their subscripts are different because they are numbered the other way. These subscripts become the same as his by changing their sign and adding $(s + 2)$.

(3) Let any general multiplier be denoted by the sign $[q]_n$ instead of D in equations (3) and (4), and let the enclosed q be the subscript of the pier moment that is to be found, and let its own subscript n denote the place of that multiplier in its own series. There being as many series as there are pier moments. Also assume that $[q]_1 = 0$, $[q]_2 = 1$, $[q]_{s+1} = 0$, and that all the Z^s in equation (4) = 0 except Z_q , then we have

$$[q]_{q-1} l_{q-1} + 2[q]_q (l_{q-1} + l_q) + [q]_{q+1} l_q = Z_q \quad (5)$$

These multipliers in this form must be transformed, because this is altogether too complex a formula.

Now the equations for the determination of $[q]_n$, where n is equal to or less than q , are the same as those for c_2 , c_3 , &c. Hence

$$[q]_n = c_n \text{ for } n = \text{or } < q \quad (6)$$

Also the equations for determining the relation between $[q]_n$ and $[q]_s$ are the same as those for the relation between d_n and d_s , and, therefore, we have

$$\frac{[q]_n}{[q]_s} = \frac{d_n}{d_s} = d_n \text{ since } d_s = 1 \quad (7)$$

$$\text{for } n = \text{or } > q$$

and making $n = q$ Eq. (6).

$$[q]_s = \frac{c_q}{d_q} \quad (8)$$

and therefore

$$[q]_n = \frac{c_q}{d_q} d_n, \text{ for } n = \text{or } > q \quad (9)$$

and by substitution in Eq. (5), we have

$$c_{q-1} l_{q-1} + 2 c_q (l_{q-1} + l_q) + \frac{c_q}{d_q} d_{q+1} l_q = Z_q \quad (10)$$

This, however, may be simplified still more by a little

reduction. The corresponding equations for the c and d multipliers are:

$$c_{q-1} l_{q-1} + 2 c_q (l_{q-1} + l_q) + c_{q+1} l_q = 0 \quad (11)$$

$$d_{q-1} l_{q-1} + 2 d_q (l_{q-1} + l_q) + d_{q+1} l_q = 0 \quad (12)$$

and from Eq. (11), we get

$$c_q d_{q+1} - c_{q+1} d_q = \frac{Z_q d_q}{l_q} \quad (13)$$

Multiply Eq. (11) by d_q and Eq. (12) by c_q and subtract, and we have

$$(c_{q-1} d_q - c_q d_{q-1}) l_{q-1} - (c_q d_{q+1} - c_{q+1} d_q) l_q = 0 \quad (14)$$

whence by comparison with Eq. (13)

$$Z_{q-1} d_{q-1} = Z_q d_q$$

and since q may have any of the successive values from 2 to s , inclusive, we have

$$d_2 Z_2 = Z_q d_q = d_s Z_s = Z_s = c_{s-1} l_{s-1} + 2 c_s (l_{s-1} + l_s) \quad (15)$$

because $d_s = 1$ and from Eq. (10) making $q = 2$

$$2 d_2 (l_1 + l_2) + d_3 l_2 = d_2 Z_2 = Z_s \quad (16)$$

If we use Mr. Merriman's notation this would be

$$2 d_s (l_1 + l_2) + d_{s-1} l_2 = d_s Z_2 = Z_s$$

The identity of this expression with Z_s is apparent as soon as we find the numerical values of the multipliers, but *seems to have been treated hitherto as a mere coincidence* by most authors, including Mr. Merriman himself. It simplifies formulas and also furnishes a valuable check on the calculations.

By the aid of Eqs. (6), (9) and (15), the formula for the pier moment becomes apparent, and is

$$\begin{aligned} M_q = & \frac{d_q}{Z_s} (c_2 y_2 + c_3 y_3 + \&c. + c_{q-1} y_{q-1} + c_q y_q) + \\ & + \frac{c_q}{Z_s} (d_{q+1} y_{q+1} + d_{q+2} y_{q+2} + \&c. + d_{s-1} y_{s-1} + \\ & + d_s y_s) \end{aligned} \quad (17)$$

and the rule for writing this formula is very simple. Thus

let y_n be any final term. Then if n be equal to or less than q its numerator coefficient is $d_q c_n$, but if n be either equal to or greater than q it becomes $c_q d_n$. For $n = q$, the coefficient is $c_q d_q$.

Hence,

$$M_1 = M_{s+1} = 0$$

by this formula also.

Now since the values of the y^s have not entered the discussion, we may assume *any arbitrary values whatever* for them. If, however, we use the usual values as given in works on the continuous girder, then for supports all on a level and only one span loaded, this formula is the same as Mr. Merriman's, since only two of the y^s appear in the formula, all the rest being put $= 0$. It must be remembered, however, that in this formula the subscripts of the d multipliers have been changed. This agreement with Mr. Merriman's formula is, of course, the necessary result of using his system of multipliers. There is, moreover, no special reason why the quantities l_1, l_2 , &c., should be real and positive except the nature of the problem usually solved in this manner, viz: the continuous girder. Hence, if necessary, these may either be negative or imaginary also.

In order to test this formula by the "Three Moment" Equation, we must write the formulas for M_{q-1} and M_{q+1} which are developed the same way:

$$M_{q-1} = \frac{d_{q-1}}{Z_s} (c_2 y_2 + c_3 y_3 + \&c. + c_{q-1} y_{q-1}) + \frac{c_{q-1}}{Z_s} (d_q y_q + d_{q+1} y_{q+1} + \&c. + d_{s-1} y_{s-1} + d_s y_s) \quad (18)$$

$$M_{q+1} = \frac{d_{q+1}}{Z_s} (c_2 y_2 + c_3 y_3 + \&c. + c_{q-1} y_{q-1} + c_q y_q + c_{q+1} y_{q+1}) + \frac{c_{q+1}}{Z_s} (d_{q+2} y_{q+2} + \&c. + d_{s-1} y_{s-1} + d_s y_s) \quad (19)$$

Multiply Eq. (18) by l_{q-1} ; Eq. (17) by $2(l_{q-1} + l_q)$, and Eq. (19) by l_q , and add the products and arrange as coefficients of $y_2 y_3$ &c. — y_s . The quantities $c_2 y_2, c_3 y_3$ &c., up to and

inclusive of $c_{q-1} y_{q-1}$, will have a common numerator coefficient.

$$= d_{q-1} l_{q-1} + 2 d_q (l_{q-1} + l_q) + d_{q+1} l_q = 0 \text{ [Eq. (12)]}$$

The numerator coefficient of y_q will be

$$d_q c_{q-1} l_{q-1} + 2 c_q d_q (l_{q-1} + l_q) + c_q d_{q+1} l_q = Z_q d_q = Z_s \text{ [Eq. (10)]}$$

The numerator coefficient of $d_{q+1} y_{q+1}$, $d_{q+2} y_{q+2}$, &c., up to and inclusive of $d_s y_s$, will be

$$c_{q-1} l_{q-1} + 2 c_q (l_{q-1} + l_q) + c_{q+1} l_q = 0 \text{ [Eq. (11)]}$$

and the equation of "Three Moments,"

$$M_{q-1} l_{q-1} + 2 M_q (l_{q-1} + l_q) + M_{q+1} l_q - y_q = 0$$

is fully satisfied, *which was to be proved.*

I have thus demonstrated that there is no theoretical necessity either for the hypothesis of single spans in succession loaded, or for the use of b multipliers dependent on the cubes of the spans or any hypothesis as to heights of supports, but that all can be solved by the aid of Mr. Merri-
man's c and d multipliers alone by this method.

Moreover, while I have written of pier moments and spans, the argument would have been fully as valid if I had called them simply unknown quantities and their coefficients, if the equations followed the same law. It is, therefore, a solution of any set of equations relating to any subject whatever if these equations have the form of those of the "Three Moments."

ELECTRIC WELDING.*

BY C. J. H. WOODBURY, Boston, Mass.

The smith is the highest type of handicraftsman; he, alone of all artisans making his own tools and also those of others, commands the dependence of all upon his offices. His work is pre-historic, reaching beyond records or traditions and known to have existed in still earlier times through the personifications of mythology, wherein Vulcan was essential to other divinities. The blacksmith is a factor in every stage of the history of mankind; and his work is now, and always has been a matter of individual skill, depending upon a keen eye and steady hand, with a fine sense of form and dimension, untouched by the flood of invention which has modified or even recast other methods of production.

It is true that machinery is used in welding, but it is merely devoted to the application of power to supplement the limits of human strength; and with trip hammer and crane the same skill is necessary as with hammer and anvil.

Since the first of the year there has been a commercial application of electric welding, the invention of Prof. Elihu Thomson, which has already reached a degree of importance sufficient to render it a live issue in every branch of manufacture to which it has been shown to be applicable.

This process is a new art, for unlike the smith who is confined to iron, steel and platinum, it can weld any two pieces of the same metal or alloy ranging from the most refractory metals to the alloy which fuses at 162° F. It will join dissimilar metals when the welding point of one is not too far in excess of the fusion point of the other.

These results seem to indicate that the classification of metals into welding and non-welding has been due to im-

* Presented at the Twenty-third Meeting, Scranton, Pa., Oct., 1888. American Society of Mechanical Engineers. Advance sheets from vol. x. *Transactions*, cccxxix.

perfections in the ordinary and time-honored methods, rather than any peculiarity in physical constitution warranting such arbitrary classification.

It is true that some of the metals have been joined without solder by means of the autogenous soldering process, wherein local fusion is produced with an oxy-hydrogen blow-pipe, but that laboratory experiment is not a union of metals heated to a plastic condition which precedes fusion, according to the accepted meaning of welding.

Passing by the scientific interest of electric welding, a short allusion will be made to the principles upon which it is based, as preliminary to a description of the apparatus, and then consideration will be given to its practical applications.

THE PRINCIPLES.

All forms of matter possess in varying degree the susceptibility of permitting the molecular motion necessary for the transfer of electric energy; those whose characteristics are favorable for such motion being termed conductors, and those which do not readily permit such motions being called non-conductors or insulators; and various adjectives are frequently used to express in a general way some sense of their value, but throughout the whole list of all known matter, there is some measure of conductivity, and the whole expression is one of degree; the conductivity of silver, for example, being over one hundred billion times that of glass; and other materials possess measures of conductivity lying between these extremes. The ability of any body to conduct electricity in comparison with others of its kind is directly as the area of the cross-section and inversely as the length.

Whenever electricity is provided with what is termed a good conductor, it makes no manifestation of its presence, but if there is poor conductivity by reason of small cross-section or poor conductivity of the material, there is resistance to the electricity. Then a portion of the electric energy is expended in producing excessive molecular motion, and converted into heat, which is radiant if the temperature

is high enough, as in the case of the incandescent light, when the metal portion of the circuit possesses ample conductivity to carry the electricity without appreciable heating, but the carbon filament in the lamp is a poor conductor, both in regard to physical characteristics of the material and small cross-section, and the molecular motion is so violent as to produce a temperature sufficiently great to contain light rays.

The total amount of mechanical work done by a current C in overcoming a resistance R during a time T , is RC^2T ; and the equivalent amount of heat is obtained by dividing the expression by J , the mechanical equivalent of heat.

$$H = \frac{RC^2T}{J}.$$

In an induction coil, electricity of large current and low pressure is converted into an equivalent electrical energy of small current and high pressure, by means of a bar of soft iron or a bundle of wires, wrapped with two coils of insulated wire of different lengths and diameters. An alternating current being sent through the shorter wire alternately magnetizes and demagnetizes the iron bar with reversed magnetic polarity, and reversals of magnetism in this bar in turn produce an alternating current in the circuit of which the secondary coil is a portion; the secondary current being as stated above of high potential and small quantity.

By suitable structural changes, an induction coil can be inverted as to its functions, and used to convert small electric currents into large ones, with inverse changes in potential.

THE APPARATUS.

The electricity is generated by one of two methods. In the direct system, the dynamo is contained in the machine below the clamps, and the armature contains two windings; the one being a fine winding which is in series with the field magnet coils, and the other winding being merely a bar of copper in the form of a letter U or less than a single

coil. This bar being of very low resistance, the maximum current is sufficient for welding purposes, and the terminals are connected directly to the copper clamps. Alternating currents are generated in this machine, and used for welding, in order to avoid commutators, which are necessary in direct current machines. It should be remembered that in all dynamos the electricity is generated in alternating currents, and that these currents are in proper turn fed to brushes of opposite polarity, and thus rendered continuous. In an alternating current dynamo, the electricity is conducted from the armature to rings instead of to a commutator, and is thus better suited for large currents, and some forms of the apparatus do not require rings or any moving contacts. There is no electrical reason why an alternating current should be used, except the convenience of its manipulation. In fact, the continuous current supplied by secondary batteries has been used for this purpose.

Another form of apparatus, termed the indirect system, is more conveniently suited for large work, or in places where a number of welding machines are operated by the current from a single dynamo. The welding current is produced by conversion of the comparatively high tension current by means of an inverted induction coil, termed a transformer. The primary circuit from the dynamo is conducted through many turns of fine wire wound round a soft iron ring, and upon this same ring is a single turn of a large copper bar in which the welding current is produced by inductive effect. These currents receive 4,000 to 15,000 alternations per minute. The welding currents are not changed suddenly or by switches, as such manipulation would not be desirable or even practicable with the great currents used ; but in the direct welding machine, a set of resistance coils is placed in the fine circuit which passes around the field magnets, and by interposing more or less of the resistance coils in this circuit, the strength of the magnets is diminished or increased, and the welding current altered accordingly.

With the indirect machine, the amount of the secondary or welding current is controlled by varying the current in

the primary coil by means of a variable shunt to the field coils and in other ways.

In either case the apparatus is simple, and is in full and complete control at will of the operator by the movement of a lever, and this action controls the heat.

THE PROCESS.

In the electric welding process, the two pieces to be joined are secured in firm end contact by a pair of adjustable copper clamps which are placed upon the top of the apparatus. An electric current of large volume is passed through the pieces, and the contact between them being of less conductivity than the homogeneous metal, heating ensues at this place, as the juncture is brought to the proper temperature by the gradual motion of the regulating lever, and as the metal softens, the clamps are pressed towards each other to insure a continuous metallic union across the bar.

The weld begins at the centre and proceeds radially towards the surface, as the temperature becomes greater than at the interior. The heating is further increased by the fact that the resistance of the hot metal is greater than that of cold metal.

The enormous electric currents used in this welding process sometimes reach 50,000 amperes, but with an electromotive force of half a volt, and therefore not capable of giving any sensation to a person.

It would be injudicious to offer any premium upon ignorance, but the operation of electric welding is one of the simplest of mechanical processes, requiring but little skill on the part of the operator in comparison with that exact training of hand and eye and long experience necessary for ordinary welding. The operator must understand the color of the proper welding heat of the metal under treatment, but this is readily learned. The work is not manipulated during the process, except when it is desired to reduce the burr at the weld, and is at all times under observation, and its heat subject to entire control by means of a lever which graduates the strength of the current.

The dynamo generating the electricity is self-regulating, and requires no attention except for lubrication.

There is no unnecessary waste of fuel, as the heating, being local, does not extend far from the weld; cotton-covered wire, one-fourth of an inch in diameter, can be welded without searing the insulation over three-fourths of an inch from the weld.

The time for making a weld varies from a fraction of a second to about two minutes, according to the work; although nothing over two inches diameter has yet been welded, but larger machines are in process of construction.

It is not necessary to provide motive power fully equal to the maximum demand, as the time is so short that the momentum of a fly-wheel will serve the same purpose as in a drop press, and give up the surplus energy required.

The power is inversely proportional to the time and appears to be about proportional to the 2.3 power of the diameter in inches, with a slight variation in favor of quick work, caused by differences in rates of thermal conductivity of the material.

APPLICATIONS.

The process is far cheaper than that of hand welding, and also extends to other methods of manufacture, but the comparative expense differs according to the previous conditions in every place where it has been applied thus far.

Its applications in practical work thus far have been confined to butt welding for many purposes, such as continuous wire work, carriage work, axles and tires, cotton-bale ties, barrel hoops and wire cables and many miscellaneous purposes. Axes are made of drop forgings, joining the tool steel edge to a mild steel poll, bars are heated in the middle and upset forming collars, and pipes are joined together—a matter of great value in ice machines. The list might be continued to greater length, but this indicates the range of its practical uses at this early day.

STRENGTH OF ELECTRIC WELDS.

The value of the process, for most purposes, independent from any scientific interest or mechanical ingenuity shown

ORDNANCE DEPARTMENT, U.S.A.—REPORTS OF TESTS BY TENSION OF BARS JOINED BY ELECTRIC WELDS, AT THE TESTING MACHINE, U. S. ARSENAL, WATERTOWN, MASS.

Test No.	Marks.	Metal.	SECTIONAL AREAS.			TENSILE STRENGTH.		Position of Fracture.	Appearance of Fracture.	REMARKS.
			Inch.	Sp. Inch.	Inches.	Total Pounds.	Sq. Inches.			
4,695	Wrought iron, . . .		3 7/16	1 7/4 diam.	2 3/8	79,640	45.070	3 1/2 in. from middle of weld.	Fibrous gr. spot at circumference.	Weld finished with hammer
4,696	"	"	3 5/16	"	1 1/2	57,090	49.500	At weld.	Gr.	"
4,697	"	"	3 5/16	1 1/2	1 00	71,542,690	53.730	3 inches from weld.	Fibrous.	"
4,698	"	"	11 9	Not welded.	1 1/2	408 21,920	53.530	"	"	Has been heated at middle.
4,699	"	"	11 9	"	1 02	408 21,840	53.530	"	"	"
4,700	"	"	11 9	"	1 02	408 22,780	55.830	"	"	"
4,701	H. D.	"	13 1/2	1 02	1 02	408 20,100	49.260	At weld.	"	"
4,702	H. D.	"	12 8	1 02	1 02	408 21,020	51.520	"	"	"
4,703	H. C.	"	12 8	1 17	1 48	408 21,820	53.480	3 inches from weld.	"	"
4,704	H. C.	"	12 9	1 14	1 45	408 21,810	53.480	At weld.	Dull fibrous, in part gr.	"
4,705	H. H.	"	12 9	1 13	1 49	408 20,400	50.000	"	" and spongy.	12,000 lbs. comp. accidentally applied before tension test.
4,706	H. H.	"	12 9	1 18	1 51	408 22,240	54.510	2 1/2 inches from weld.	Fibrous.	"
4,707	W.	"	12 8	1 18	1 47	408 21,780	53.38	3 7/8	"	"
4,708	"	"	12	Not welded.	1 50	196 12 540	53.880	At the grip.	"	Has been heated at middle.
4,709	"	"	12	"	1 50	196 11,160	50.940	"	"	"
4,710	"	"	12 2	"	1 50	196 10,520	53.670	"	"	"
4,711	H. D.	"	13 2	1 43 diam.	1 89	186 7,691	39.230	At weld.	Dull fibrous, part of surface smooth.	"
4,712	H. D.	"	13 35	1 50	1 96	9,980	50.920	"	Dull fibrous, and spongy.	Started fine crack at weld.
4,713	H. H.	"	13 2	1 60	2 83	196 10,260	52.350	1 1/2 inch from weld.	Fibrous.	Fractured at weld at the anvil by bending cold.
4,714	H. H.	"	13 2	1 60	2 83	196 10,280	52,450	1 7/8	"	Fibrous, part of surface smooth.
4,715	H. C.	"	13 35	1 56	2 46	106 11,080	56.530	1 7/8	"	"
4,716	H. C.	"	13 2	1 61	2 92	190 10,270	52.4	1 1/8	"	"
4,717	H. W.	"	13 1	1 67	3 53	196 11,170	56,900	1 5/8	"	"
4,718	H. W.	"	10 25	1 72	3 07	16,750	53.690	2 1/4 inches from weld.	Fibrous seamy	"
4,719	H. D.	"	16 25	1 76	4 54	24,550	54.070	At weld.	Gr. at circ., dull centre.	"
4,720	H.	"	16 1	1 88	4 68	25,590	42.100	2 inches from weld.	Fibrous.	"
4,721	H.	"	16 4	1 81	5 15	25,340	40.300	2 inches from weld.	Fibrous.	"
4,722	H. D.* Steel.	"	17 5	5 99	1 98	15,300	77.270	At or near weld.	Gr. medium coarse.	"

Correct

J. E. HOWARD

F. H. PARKER,

Lieut.-Col. Ordnance Dept. U. S. A., Commanding.

MACHINE, U. S. ARSENAL, WATERTOWN, MASS.

4.753. A chain made of three links of .50 inch diameter wire. Two welds in each link at the sides. Tensile strength, 17,000 pounds. Fractured middle link in the quarter 1.65 inch from weld. Appearance fibrous

in the apparatus, must be that of the resistance of the welds under tensile stress.

It will readily be understood, however, that, as this process accomplishes many things hitherto impossible, aside from any question of ultimate strength, it is fitted for applications in many constructions where it saves labor and time; provided only that the joints be in all cases sufficiently good for the purpose for which the article is designed. A large field thus opens up in the execution of ornamental design in metal work, where it will supplant screws, rivets or solder for fastenings, and in other evident applications.

There is no reason why such a weld should be stronger than the rest of the bar, but if averaging of equal strength some of the breaks would occur at the weld. There have been many tests made on various testing machines, but it has been considered preferable to submit only the official record of tests made on the Emery Testing Machine at the U. S. Arsenal at Watertown, Mass. (*See accompanying table.*)

[There were exhibited a number of specimens of electric welding showing the range and capability of the process.]

A PERFECT SUBSTITUTE FOR GLASS AS A SUPPORT FOR GELATINE BROMIDE OF SILVER
FOR USE IN PHOTOGRAPHY.

BY JNO. CARBUTT.

[*Read at the Stated Meeting, Wednesday, November 21, 1888.*]

Vice-President CHAS. BULLOCK, in the Chair.

No sooner had the gelatine dry plate process become established, displacing by its greater sensitiveness and convenience the old wet and dry collodion method, than experiments were commenced to find a suitable substitute for glass, the weight of which has proved a great inconvenience to travellers, with the dread always present that their exposed plates or negatives might get broken ; a dread, in many instances, only too painfully realized. Before proceeding to describe the material I have found to be a perfect substitute for glass as used in photography, I will briefly pass in review a few of the substitutes suggested and made use of, and note the objections to them.

In 1880, M. Ferrier, of Paris, patented a compound film of gelatine and collodion. The objection to this film was the unequal expansion of the gelatine and collodion, causing the latter to crack.

H. J. Palmer, M.A., of Liverpool, in 1881, proposed a film of gelatine and ox-gall, with a second film of plain gelatine.

Stebbing, of Paris, produced gelatine bromide films on a pellicle of gelatine. Both this and the Palmer film proved defective from the liability of the film to expand while in the developing solution, sometimes to nearly double the area of the dry film.

Warnerke, of London, produced films of alternate layers of rubber and collodion.

Pumphrey, of Birmingham, as early as 1882, produced films on paper.

Morgan & Kidd, of London, coated paper for bromide enlargements, and the same was used for paper negatives, but the grain of the paper proved objectionable.

The late Walter B. Woodbury devoted a great deal of time in trying to produce a transparent paper as a support, when death overtook him. His partner, Vegara, took it up, and finally placed such films on the market, only to be shortly withdrawn, to be replaced by a film of hardened gelatine, the invention of F. C. Froedman, of Dublin. His method consists in mixing bichromate of potash with gelatine, spreading on glass, drying, exposing to light, washing in plain water, then bleaching in a dilute solution of sulphurous acid, again washing, drying and coating with sensitive emulsion. The objection to this film is its extreme limpness when wet, and propensity to assume any shape but a flat one on drying. These were followed in America by the Eastman Company's paper negative, made translucent with castor-oil, and while printing quicker than paper un-oiled, the objectionable grain of the paper marred the result.

Next we have the stripping film of the same company, which up to the present time has proved the best substitute for glass, although in many instances the grain of the paper shows in the finished negative. The objection made by users of this material is the great risk of loss of negatives in the after-process of stripping the exposed film from its paper support and the time occupied in the same. I will read from their instructions as published in *Science of Photography* (Vol. I, pp. 11, 12):

“*Stripping.*—Take as many sheets of glass as you have negatives to strip, each one a size larger than the negatives. Clean, and when dry coat with a rubber solution, which can be either bought already prepared or can be made as follows :

	Oz.
Rubber cement, ...	1
Benzine, ...	9

“Place the plates in a rack to dry until ‘dead,’ which

will take about five minutes. Then flow with the following solution :

"Plain Collodion.—

	Oz.	Grs.
Ether, ...	1	0
Alcohol, ...	1	0
Gun-cotton, ...	0	10

"As soon as set wash under the tap until the greasy lines disappear. This is to remove the ether and alcohol. Then place the glass in a tray half-full of cold water, keeping hold of one end with the left hand. Put the negative into the dish face down, press under the water and guide the end nearest the hand holding the glass, so as to clasp the negative with that hand, then raise the *end* of the plate out of the water, thus allowing the water to carry the air from under the negative. Squeegee the negative down, which should be done with light pressure for the first few strokes, and then put it under blotting paper with another sheet of glass over that, and a weight of say eight or ten pounds on it. Allow it to remain under pressure for ten minutes. Now take a tray half filled with warm water at a temperature of about 110° F., or such as will feel comfortable to the hands. The directions sent out with the films, saying to use water at 120° to 140°, I have found to be much too hot.

"Place the glass plate with the negative thereon into the warm water, and, after gently rocking a couple of minutes, try one corner by picking it up with finger-nail or a pin. If it does not start readily do not try to hasten it, for as soon as the water has softened the substratum the paper will come off easily. After the paper is removed raise the plate from the water, wash off the remaining soft gelatine with a tuft of cotton or camel-hair brush dipped in warm water, and set the plate in a rack to cool. Do not change from the warm water to the cold too quickly, as a sudden change of temperature will frill the gelatine.

"After the negative is cool place it in a pan of cold water, holding the fingers under one end of the plate. Take a gelatine skin and slide into the water, smooth side down. Clasp the end of the skin with the hand holding the glass.

and with the other hand press the skin under the water. As soon as the skin is immersed raise the end of the plate slowly, which allows the water to carry the air from between the skin and negative.

"In placing the skin on the negative do not allow it to remain in the water more than thirty seconds or a minute, as the water will soak out the glycerine, and the skin when dry will become brittle. To avoid this tendency it is well to put about ten per cent. of glycerine into the water used for that purpose, or perhaps better yet is a solution of equal parts of wood alcohol and water, which may be kept in a bottle and used from time to time.

"With a wet squeegee go over the skin carefully until all the wrinkles are removed, when allow the negative to dry thoroughly, and flow with plain collodion. As soon as this is dry, cut around the edge and peel from the glass. The rubber adhering can be removed with a tuft of cotton dipped in benzine.

"The negative when completed has a coating of collodion on both sides. This forms a protection against moisture, and gives the negative greater flexibility. I am frequently asked, are the films quick enough for instantaneous work? In reply, I say, most assuredly, yes. A short time ago I made some 8x10 negatives of the New York and Philadelphia Express going at the rate of forty miles an hour. I was on the shadow side, but the negatives were fully timed and showed remarkable detail in the deepest shadows. The train was perfectly sharp, and the driving rod of the engine plain and distinct.

"For interiors, or any work where halation is liable to occur, films are vastly superior to any glass plates, as they do not show halation. I have many negatives giving unquestionable proof of this."

The substance I have the honor to bring to your notice to-night is thin sheet celluloid, manufactured by the Celluloid Manufacturing Company, of Newark, N. J.

It is some three or four years since I first examined into this material, but the manufacturers had not then perfected the finish of it to render it available, and it is only during

this year that it has been produced uniform in thickness and finish, and I am now using at my factory large quantities of sheet celluloid $\frac{1}{100}$ of an inch in thickness, coated with the same emulsion as used on glass, forming flexible negative films, the most complete and perfect substitute for glass I believe yet discovered on which to make negatives and positives, and without a single objection belonging to the substances previously enumerated.

Its weight, as compared with glass, is as follows: Twenty-four 5x8 flexible films weigh seven and one-half ounces, while twenty-four 5x8 glass dry plates weigh from 110 to 120 ounces; and its great merit does not only lie in its lightness, toughness and flexibility, but in that its treatment in development, etc., is precisely that of a glass plate. There is absolutely no after-process required. When the negative is washed it is hung up by a spring-clip to dry, and is then ready to be printed from, and, owing to its thinness, can be printed from the reverse side, if the precaution is taken to use only vertical rays.

Makers of photographic apparatus are already producing light-weight holders to carry these films, and I have no doubt magazine holders will be produced in which thirty to fifty films can be carried and exposed.

I have here an old changing box I used twenty years ago, in which, by a simple device to hold the films and allow of changing from box to holder, I can carry eighteen films.

I have here several negatives made on the films and prints from them, that members can examine at close of meeting.

I will now show on the screen lantern transparencies from film negatives, both contact, and reduced in the camera.

WAYNE JUNCTION,

November 12, 1888.

MEMOIR OF JOSEPH ZENTMAYER.

JOSEPH ZENTMAYER, optician, whose name was known all over the world, and whose death is so sincerely deplored by all his fellow-members of the FRANKLIN INSTITUTE, was born in Mannheim, Baden, in South Germany, in 1826. He received a good education, and learned his trade as an instrument maker. At the termination of his apprenticeship, and after having made his "masterpiece," as is the custom among German mechanics, he travelled throughout Germany, working in the best establishments, and improving himself in the knowledge and use of scientific instruments. He was an ardent republican, and his natural love of liberty led him to take an active part in the agitation that had as its object the establishment of republican institutions in Germany.

He came to America in 1848, in the 24th year of his age, hoping to find a free scope for his notions of freedom in the Western Republic. Between 1848 and 1853, he worked for the best instrument makers in Baltimore, Washington, and in Philadelphia. In 1853, he began to make mathematical instruments in Philadelphia, at Eighth and Chestnut Streets, with but one single lathe. The high character of his work, and the boldness of his conceptions, attracted the attention of the leading scientific men. Among these, the late Dr. Paul B. Goddard was particularly drawn to him, and it was Dr. Goddard who persuaded him to make the first of his large compound microscopes. This early effort was so successful that the Academy of Natural Sciences, and many of the leading physicians who required such instruments, purchased those of his make and discarded the heavy and yet unstable instruments of European manufacture. Once fully embarked in this enterprise it seemed to absorb his whole attention, and many were the improvements that followed each other in rapid succession, not only in the stand of the microscope, but in its objectives. At the present time, there is not a maker of microscopes in the world, who does

not use some of the important inventions of this Philadelphia mechanic. During the war for the Union he furnished most of the microscopes used in the Government hospitals, and he received the highest commendation from all the officers and other authorities for his work.

The Chairman of this Committee made the acquaintance of JOSEPH ZENTMAYER in 1861, and from that time until shortly before his final illness, enjoyed the most intimate and agreeable relations with him, of a social, scientific and business character.

During these many years Mr. ZENTMAYER devised and constructed a great variety of apparatus, which was used in researches or in the illustration of lectures.

The success of these researches and the effective illustration of these lectures, were largely due to the ingenuity and genius of Mr. ZENTMAYER in devising, and to his accuracy and delicacy of workmanship in executing this apparatus. Accounts of the structure and operation of some of these pieces of apparatus will be found in the JOURNAL OF THE FRANKLIN INSTITUTE, 1865, vol. 79, p. 421; 1866, vol. 82, p. 66; 1867, vol. 83, p. 406; 1868, vol. 85, pp. 64, 345, 207, 345. Also in the *Philadelphia Photographer*, 1867, vol. 4, p. 218, p. 231.

In many instances portions of this apparatus had to be ready at short notice, as in the case of some lectures at the Academy of Music, and their completion involved special exertion and prolonged hours of work. In all such cases Mr. ZENTMAYER'S willingness and enthusiasm were of a character which should never be forgotten.

His interest and anxiety for the success of the experiment seemed fully equal to those of the lecturer himself.

In 1865, he invented his photographic lens. The story of his invention of this photographic objective is very interesting. At the time when the Harrison globe lens was attracting attention one member of this committee, Prof. Coleman Sellers, was requested to write a paper for the *American Journal of Science and Arts* on the nature and advantages of the globe lens for the photographic camera. After this was published, its writer consulted Mr. ZENTMAYER about the combination, and he said that it was quite possible to make

a lens of two simple uncorrected concavo-convex or meniscus glasses, made thin and of proper curves, and that such a lens would be chemically correct as to focus, and would also copy a drawing with the marginal lines straight, that is, without any bending of the lines either out or in. He was urged to make a lens of this kind, and finally he did so, sending it to Prof. Sellers to test. That first lens, made as he had proposed, was perfect in its definition, and had all the good qualities he had promised. Most lenses for this kind of work have been the result of a long series of experiments ending in the form adopted. In this case a lens constructed upon a theory proved the correctness of that theory in a most remarkable manner. The Zentmayer lens, which in working is as rapid, if not more so, than other globe lenses in the market, was more simple and filled a want, inasmuch as his system enabled him to make a series of lenses, the front of one lens being used as the back one of another through a series of sizes from the longest focus wanted to the shortest; a set of these lenses, combined as required, meeting all cases that could occur both as to size of plate and proportion of reduction. Mr. ZENTMAYER'S patent for these lenses was not granted at once, but he was obliged to contest his claim before a master, in which examination his claim in regard to priority was fully sustained.

At first Mr. ZENTMAYER objected to patenting this lens, and it was only at the urgent solicitation of Prof. Sellers that he finally consented to do so. Much controversy resulted from the introduction of this objective, but it established Mr. ZENTMAYER'S reputation as a photographic optician of the first rank.

So radically original was the invention embodied in this lens, that the descriptions of it were at first regarded by the practical opticians of Europe as incredible and as American exaggerations, and these ideas led to quite an animated controversy, which may be found in the *JOURNAL OF THE FRANKLIN INSTITUTE*, 1867, vol. 83, p. 349; also, 1868, vol. 85, p. 153, and more fully in the *Philadelphia Photographer*, 1867, vol. 4, pp. 177, 251, 253, 344; also, 1868, vol. 5, pp. 79, 109.

This lens was first described in the JOURNAL OF THE FRANKLIN INSTITUTE, 1867, vol. 82, p. 63, and reports on its performance by a Committee of the Photographic Society of Philadelphia were published in the *Philadelphia Photographer*, 1867, pp. 44, 151.

When, in 1869, the Chairman of this Committee organized the party to make photographic observations of the total solar eclipse visible in Iowa on the 7th of August, Mr. ZENTMAYER devised and constructed the special photographic lenses which replaced the eye-pieces, and also the drop-shutter attachments for regulating the times of exposure, used with the equatorial telescopes employed on that occasion.

During the preliminary rehearsals and experiments in West Philadelphia, where a temporary observatory was constructed and two of the equatorials were set up, adjusted and operated in making photographs of the sun and moon, Mr. ZENTMAYER was indefatigable in assisting the work, day and night. He also joined the party and went with it to Ottumwa, Ia., where his knowledge and fertility in resources to meet unexpected difficulties contributed largely to the success achieved by that section of the party. All this personal work at Philadelphia and in Iowa was a voluntary, gratuitous, contribution. A description of the above-mentioned apparatus and of the work done with it will be found in the JOURNAL OF THE FRANKLIN INSTITUTE, 1869, vol. 88, pp. 200 to 216, *Les Mondes*, v. 21, p. 228; also in the *Philadelphia Photographer*, 1869, vol. 6, p. 305; also in the *Reports of the Observations of the Total Eclipse of the Sun, August 7th, 1869*, published by authority of the Secretary of the Navy, p. 115.

After the system of screw-threads, known as the "United States," or the "FRANKLIN INSTITUTE, Standard System of Screw-Threads" was introduced, and makers called for instruments to measure the amount of reduction or the width of the flat top and bottom of the threads, a set of thin steel plates ground to an angle of 60° was sent to Mr. ZENTMAYER to have him grind the apex of each to the proper amount. The width of each being given to him "in decimals of an

inch to the fourth point. In topping these off he measured the flat by means of a stage and eye-piece micrometer. The correctness of his work was then verified by a member of this Committee, who, taking the finished pieces, measured them on his own microscope in the same manner, setting down the dimensions as found, and afterwards comparing them with what was required, with the result of finding them correct to the fourth place of decimals in each case. This was, in the first place, one of the earliest instances in which the microscope was used in such a mechanical process, and a remarkable example of the facility with which good instruments can be used in such work of precision. The standard gauges, made since by the Brown & Sharpe Manufacturing Company, have all been adjusted to the standard pieces prepared by Mr. ZENTMAYER.

The wonderful comparator, designed by Prof. Rogers, of Boston, and made and used by the Pratt & Whitney Company, of Hartford, Conn., is furnished with microscopes made by Mr. ZENTMAYER, who took great pains to perfect the instruments to be applied to this system of comparing measurements. In all cases where work of great nicety has been required, those who knew Mr. ZENTMAYER's skill were in the habit of seeking his aid, even in matters not pertaining to optics. The freedom from petty jealousy that marked his character was pleasing to his many friends. No one ever heard him say a harsh word about rivals in trade, even when in the contests, called by some sharpness in trade, he might justly blame some for having acted unfairly. Those who have been for years in the habit of visiting him in his shop, know how kind he always was and how patiently he listened to what they had to say, giving freely from his great store of knowledge, showing his methods and even supplying to those who wished to make any piece of apparatus themselves such parts as he could find suited to their purpose.

Mr. ZENTMAYER's office in Walnut Street, where he had his lathe close to his counter and near to the cases containing his instruments, was the meeting place of all the scientists of the day. There, at all times, while he was work-

ing, professors and physicians and mechanical engineers would meet and discuss problems in optics or in mechanism; all of these men learning to love the good man who was so simple-minded, and so honest in his dealings. Many times young men, coming to purchase their first microscope, found the great optician advising the purchase of a good working instrument, cheaper than the one they had come to buy, but well fitted to do what would be required of it. No instrument would leave his hands without being personally inspected by him, after he had advanced to the condition of employing workmen to do what at first he did with his own hands. All those who knew Mr. ZENTMAYER felt the influence of his honest, straightforward seeking after truth. It was always a source of pride to him that among the many thousand instruments which he constructed, none ever came back for repair after years of hard usage, except in the case of severe accident, such as would come from a fall, or the like. No amount of work ever did them harm.

The great triumph of his microscope-making was the perfection of the stand, known as that of 1876, which elicited so much favorable comment during our Centennial Exhibition. The invention and practical application of his swinging sub-stage, that enabled him to rotate the illuminating apparatus completely around the object without disturbing its focus, were marked examples of his talent. Others may claim to have made something similar, but none had ever made it so perfect as to be substantially new to all who used it. Now no good microscope is made without this important arrangement of the stand. The binocular microscope, under his hands, became more useful than ever before. It was not until he had perfected this form that he was willing to sell a binocular instrument. He knew the good that was to be obtained by means of the binocular principle, but he was unwilling to make one for sale until at last he had surmounted all the objections he saw in the system, and had made so perfect an instrument that he did not fear to attach his name and reputation to it.

In the construction of his simple form of sliding stage others may claim the prior invention of the principle in a

crude form, but it is very certain that to Mr. ZENTMAYER, and to him alone, is due the credit of making this simple device as perfect as the most costly compound stage, so far as comfort of working and certainty of motion is concerned. To suggest is one thing, but to perfect into an efficient instrument is perhaps the most important after all.

Mr. ZENTMAYER was not willing to push himself forward, but when he at last was persuaded to lecture on optics at the FRANKLIN INSTITUTE, his lecture proved to be as well worthy of the man as all his mechanical work. It stands to-day as an important addition to the literature of optics.

Mr. ZENTMAYER'S musical education, as well as his artistic, made him an appreciative critic, and among his countrymen his poetry is valued. He was so loving and so kind, so winning in his ways, that all who came in contact with him were attracted towards him, and when his last illness came, warning them that the mind they had valued so highly was losing its great strength, they mourned his death long before the actual dissolution of his body.

After leaving Philadelphia, in 1870, the Chairman of this Committee saw, of course, less of Mr. ZENTMAYER, although he had the pleasure of having him stay at his house in Hoboken on several occasions, once in company with the German scientist H. Vogel, and on another occasion with the eminent investigator and constructor of acoustic instruments Rudolph Kœnig; the Chairman, however, always kept up a correspondence with Mr. ZENTMAYER and sought his assistance whenever he had need of any instrument involving especially fine and accurate workmanship.

No words that he could use would be too strong to express what he knows of Mr. ZENTMAYER personally as a man of high intellectual acquirements, refined tastes, pure morality and a sincere amiability which enabled him to think and speak only kindly even of those who had not treated him well, and which unspeakably endeared him to all who enjoyed the privilege of his friendship.

The illness that at last resulted in the death of Mr. ZENTMAYER came on very slowly, and fortunately only after he had instructed his sons in the processes that had made his work

so celebrated. Those sons have had charge for a number of years of the construction of the instruments which have given such great satisfaction to all who have used them. To members of this Committee the father confided his system of education of his children, and to them he explained how thoroughly he had informed them of the minutiae of his operations, that they might worthily carry on a business of which he was so proud. Mr. ZENTMAYER would never do any work slightly. What was to be done must be done well, his constant effort being to improve his methods as well as improve the construction of his instruments.

His inventions, that have carried the name of ZENTMAYER to all parts of the civilized globe, were not made rapidly, as a rule. He pondered over all his improvements for a long time, and they all show deep thought. Those who knew him best remember the look of deep thought impressed on his speaking face when they called and found him alone with his big dark-colored working microscope before him. They knew he was being interrupted in work that would soon add some new thing to his list of accessories, or in the perfection of some instrument. With his life has gone the spirit of a pure-minded and upright man, a good citizen, a lover of liberty and a lover of truth. To the family he leaves behind him, if he has not been able to give them much worldly wealth, he certainly has given a worthy example for them to follow.

As a writer, Mr. ZENTMAYER was not prolific, preferring to express his ideas verbally to his friends, rather than to put them on paper for publication. We find, however, the following articles, which were his work, in the JOURNAL OF THE FRANKLIN INSTITUTE:

On a Mechanical Finger for Use in Mounting Diatoms under the Microscope, 1870, vol. 89, p. 334.

On an Erecting Prism, for Use in the Microscope, 1872, vol. 93, p. 375. A Lecture on Lenses, 1876, vol. 101, pp. 336 and 421.

On Improvements in Microscopes, 1877, vol. 104, p. 49.

Also in the *Philadelphia Photographer*, 1867, vol. 4, p. 251. we find an article entitled "Refraction without Dispersion,

and some Reflections," in which he takes a hand in the controversy about his photographic lens, with marked ability.

Mr. ZENTMAYER was elected a member of the American Philosophical Society in 1873, and of the FRANKLIN INSTITUTE in 1865. He received the Elliott Cresson Medal for improvements in microscopes in 1875.

HENRY MORTON,
COLEMAN SELLERS.

CORRESPONDENCE.

PHOTOGRAPHS OF LIGHTNING.

The Secretary, FRANKLIN INSTITUTE.

DEAR SIR:—In view of the fact that the Royal Meteorological Society of London, England, has recently published a pamphlet in which the Thunderstorm Committee state that after twelve months investigation it has been concluded that lightning never occurs in the zigzag form so commonly seen in pictures, I would like to call your attention to the fact that for many years the writer has held this view of the matter, and in the summer of 1882, a series of photographic experiments were made, the object being to prove the wavy line theory of lightning by means of the camera, which has been carried on since that time with successful results.

At the September meeting of the INSTITUTE, 1885, I forwarded to you a communication, together with a lantern slide showing a photograph of lightning, and drawing your attention to the fact of the wavy line character of the discharge, and its identity with the spark of an electrical machine. This photograph, with my letter in relation to the wavy line theory, was reproduced in the *Scientific American*, of September 5, 1885.

Since that time I have sent you two other photographs of lightning, and now I would be much obliged if you would exhibit at the next meeting the accompanying lantern slides in the following order:

No. 1. Photograph of lightning occurring between two clouds; taken in September, 1882.

No. 2. Photograph of lightning extending from zenith to horizon; clearly exhibiting the wavy line character of the discharge. Taken at 10.30 P. M., August 1, 1885.

No. 3. Photograph of a horizontal discharge of lightning with numerous branches, in each of which the wavy line is maintained. Obtained June 1, 1887.

No. 4. Vertical streak of lightning, which is very remarkable, on account of its lower extremity appearing to be in a molten condition. This was taken May 29, 1888.

The object of this letter is to place myself on record as being the first

practically to prove, by means of the camera, the wavy line theory of lighting, and its identity with a frictional machine spark, the results of which were exhibited in the lecture hall of the FRANKLIN INSTITUTE, in September, 1885.

The future developments in this line of photographic research are so promising, that it might become of interest some day to trace its origin.

Very respectfully yours,

WM. N. JENNINGS.

1302 BUTLER STREET, PHILADELPHIA, *October 16, 1888.*

BOOK NOTICES.

DARWINISM.—A BRIEF ACCOUNT OF THE DARWINIAN THEORY OF THE ORIGIN OF SPECIES. By David Starr Jordan, Ph.D., M.D. Chicago: A. B. Gehman & Co. 1888.

To make the "Darwinian" theory of the origin of species clear to the mind of the general reader is anything but an easy task, not so much in the understanding of the theory itself as in the vast amount of prejudice to be overcome. Although this little book does not, by far, contain all that could be desired upon the subject, the author has, nevertheless, produced a very readable and instructive dissertation upon the facts and theories of the origin of species. His explanation of the diversity of species is made very simple as he puts it. "When I compare my arm with that of my neighbor, I find differences in size and proportions. But these are superficial, and there is the underlying correspondence of each bone and muscle, each nerve fibre, artery and vein. When I compare my arm with the foreleg of a dog, I find more striking differences, for the dog's station in life is quite unlike my own, and he uses his arm for different purposes. When I compare my arm with the wing of a bird, or the pectoral fin of a fish, the results are similar. Though the differences in each succeeding case become more and more striking, and resemblances less easy to trace, yet the same resemblances exist, and a closer study shows that these resemblances far outweigh the differences." One of the strongest points the author makes are his few lines upon "special creation." "If each of the half million of species of animals and plants which now live, and each of the millions of kinds which have become extinct has been the subject of a 'special creation,' then 'special creation' is but a name given in our ignorance to the law by which species are produced." We feel sure that every true scientist will, at least in some degree, echo the author's thoughts in the following remarks upon the subject of the Darwinian theories and Christian religion. "Our objections to recognizing our kinship with the lower forms—if we have any such objections—rest on reasons outside the domain of knowledge. They do not rest on religious grounds. Those who think so deceive themselves. The question of the Christian religion is not in any sense concerned in this discussion. The Darwinian theory deals only with the methods of creation, the 'secondary causes' in the providence of God. 'Theology and science,' says Darwin, 'should each run its own

course. * * * I am not responsible if their meeting point still be far off.'"

To thoroughly appreciate and enjoy this little work, the reader should possess a pretty general knowledge of geology and its kindred sciences, otherwise the author's meaning will not always be clear. F. L. G.

ACCIDENTS AND EMERGENCIES; A MANUAL OF THE TREATMENT OF SURGICAL AND OTHER INJURIES IN THE ABSENCE OF A PHYSICIAN. By Charles W. Dulles, M.D. Third edition, 12 mo. Philadelphia: P. Blakiston, Son & Co.

This volume of 120 pages presents, in condensed form, the efforts proper to be made for resuscitating drowned persons, relief from sudden entrance of foreign bodies in the eye, nose and ear; action to be taken in regard to fits, convulsions, injuries to the brain, effects of heat and cold, wounds, fractures, dislocations, hemorrhages, railroad and machinery accidents, poisons, domestic emergencies, etc. There are illustrations of proper positions of the body and separate limbs under treatment, also directions for prompt bandaging; and the whole concludes with a list of supplies proper to be kept on hand for such use. The author makes the following sensible suggestion: "Let the volume be read through, at least once, as carefully and as studiously as possible, so that the reader may make the acquaintance of its suggestions; and then let it be kept in some handy place, where it can be referred to immediately when emergency arises."

The volume has at front a general table of contents, and at the end a detailed index, and the whole appears to be what it professes, and worthy of wide circulation. Though much in it is not new, the form of presentation and the grouping of efforts add value to what, though often heard, might be forgotten in the excitement of an emergency. N.

PLATE GIRDER CONSTRUCTION. By Isami Hiroi. New York: Van Nostrand. 1888.

The importance of the use of plate girders in construction cannot be over-estimated, especially as the last few years have shown that, with scientific designing, for economy of material and strength, they can replace with great advantage the open truss for a longer span than is generally used.

With the exception of an occasional chapter in text-books on bridges and a few paragraphs in hand-books, but little information on this subject exists. Prof. Hiroi however, in his work, has gone into the subject very thoroughly; treating of the theory exhaustively; and deducing a number of important formulæ, which can readily be applied by the practical designer and draughtsman.

To illustrate:—A plate girder, fifty feet in length is taken, and rules are given, gleaned from the best practice, for assuming an effective depth. The calculations are then made for the web and flange stresses, for both dead and live loads; and with the data thus obtained, the girder is designed with the proper allowances for riveting, splicing, stiffening, etc.

The method of making estimates for the cost is also shown, and in a summary is given some very valuable practical information concerning the details.

In the discussion of the theory, important principles and formulæ are in many cases given without sufficient explanation and demonstration, requiring for their intelligent comprehension a more thorough knowledge of advanced mechanics and bridge stresses than is possessed by the average reader. The theoretical investigation of the web stresses is somewhat novel, but is very thorough and logical. In the deduction of the flange stresses, both graphical and analytical methods are used. As the author implies a preference for the former, a more elaborate explanation of method and detail would greatly lessen the labor of a beginner. For obtaining maximum flange stresses due to live loads, by making the polar distance equal to the assumed effective depth of the girder, the calculations would have been shortened somewhat, as the desired results would then have been obtained directly.

Although the results for obtaining the effective depths, for riveting, splicing, stiffening and flange widths, vary somewhat, and in some cases considerably, from those given by a number of bridge companies, yet the context evinces such a conscientious and thorough investigation of the theory, as well as so complete a practical knowledge, that the work cannot fail to prove of value to the designer, constructor and inspector, as well as to the teacher who desires to impart its principles and suggestions to his classes.

The entire work is embraced in a duodecimo of ninety-four pages, published by D. Van Nostrand, New York City, at a price which makes it a very desirable investment.

B. F.

THE GEOLOGICAL EVIDENCES OF EVOLUTION. By Angelo Heilprin. Philadelphia. Published by the Author. Academy of Natural Sciences. 1888.

This book certainly supplies a pressing need and it especially recommends itself to educated and thinking persons who have not had the advantages of any scientific training. It is, however, to be regretted that the book has been so much condensed; indeed, this has been carried so far that in some places the language is somewhat vague, and the successive evolutionary steps have not been sufficiently simplified. One cannot read Prof. Heilprin's writings or hear his lectures without wishing they were longer, and if this little book possesses any serious fault it is in being altogether too concise.

F. L. G.

SCIENTIFIC NOTES AND COMMENTS.

ENGINEERING.

EFFICIENCY OF STEAM AT HIGH PRESSURES.—Mr. A. W. Beauman, in a paper read at the last meeting of the Mechanical Section of the British Association, shows that the Carnot theorem for the efficiency of a heat engine is limited in its application to steam-engine calculations of efficiency, and that high-pressure steam must theoretically, as well as practically, be more efficient than low-pressure steam. For some time it has been evident that the behavior of steam in a steam-engine cylinder cannot be interpreted by laws that are true for a permanent gas, and that the actual efficiency of its action is not proportional to the range of temperature used in the cylinder. It has, on the contrary, become evident that the practical efficiency is more nearly inversely proportional to the range of temperature in the cylinder; and, moreover, it has become increasingly evident that the efficiency of the actual steam engine cannot be usefully measured by any standard based on the Carnot theory of the perfect engine, as expressed by the relation

$$E = \frac{T - T_1}{T}.$$

Modern practice has amply proved that the real efficiency of the steam engine has only been increased as the special character of the working fluid has been studied and provided for. The Carnot theorem ignores the nature of the working fluid, and the endeavor to realize with steam the conditions of a Carnot engine has led to delay in the development of the steam engine. Formerly it was assumed, chiefly as a deduction from Carnot's theorem, that there could be little gain as a result of the use of high-pressure steam, because the thermal value increased so slowly with the increase in pressure. Upon the same grounds it is now generally held that the present state of our knowledge indicates that a pressure of about 200 pounds will give results equal to those which are possible with any higher pressure. This argument is strictly in accord with the Carnot function, and it is this argument which the writer proposes to show is not necessarily a true one.

The efficiency of an engine working between fifty pounds pressure and 100° F., according to Carnot's theorem, is .242. A pressure of 100 pounds gives .290, 150 pounds gives .315, and 300 pounds gives .362. Thus, according to the theorem, the gain attending the use of pressures above 150 pounds could not be sufficient to counterbalance the practical disadvantages incurred. Experience has proved that this is the reverse of the truth. Every increase in pressure has secured an increase in actual efficiency which has been far more than is necessary to cover the increased cost of obtaining it. The rate of increase has been double that which the Carnot theorem indicates, and it has been amply shown that the engines made for and supplied with steam at a high pressure work under conditions which are much more nearly those

required for maximum efficiency than do those engines which work with lower pressures.

By raising the steam pressure from sixty-five to 150 pounds, the efficiency ought to be increased by twenty-one per cent., or a saving of seventeen per cent. ought to be made. As a matter of fact a saving of from twenty to more than thirty per cent. has been achieved. It is clear, then, that the high-pressure engine is remarkably efficient, or that the low-pressure simple engine is remarkably inefficient.

Now, as the total heat of a volume of steam is within a few units as great after expansion as before it, and nearly all the fall in the quantity of heat takes place when the steam leaves the steam-engine cylinder, it is desirable to examine the relative conditions of expansion through a given range of pressure before exhaust occurs, as, for instance, 100 to 50 pounds, or 200 to 150 pounds. If a pound of steam at 350 pounds pressure expands to a pressure of 300 pounds, it will have fallen in temperature 15° , doing 10,372 foot-pounds of work. The work done by expansion per degree fall of temperature is 691 foot-pounds. Again, one pound of steam at 300 pounds expanding to 250 pounds falls in temperature 16° ; the work done is 12,235 foot-pounds, or 765 foot-pounds per degree fall in temperature. Between steam at 100 pounds and fifty pounds there is a difference of 46.8° , and the work represented by the expansion of one pound of steam from one to the other is 49,280 foot-pounds or 1,053 foot-pounds per degree. There is thus per degree fall in temperature of steam expanding from 350 pounds and from 100 pounds, respectively, a difference of $1,053 - 691 = 362$ foot-pounds.

It will be seen, therefore, that if heat disappears in proportion to work done, that the low-pressure engine cylinder for a given range of pressure must require more heat, either from a steam jacket or from steam liquefied on entering the cylinder during the admission part of the stroke, than the high-pressure cylinder.

The conclusions to which the author is at present inclined, although the paper is intended only as a preliminary consideration of the subject, are: (1) That the work done with steam in a steam-engine cylinder is not proportional to the range in temperature; (2) that steam pressures much above 200 pounds on the square inch may be used with advantage; (3) that a small range of pressure should be used in each cylinder; (4) that the number of cylinders should be as large as mechanical considerations will allow; (5) that the economy obtained by multiple stage-expansion engines, as compared with single stage expansion, is due to the small difference of temperature in a cylinder on the opposite sides of its piston; to the opportunity which the protracted working history of the steam gives, for the utilizable re-evaporation of the steam which is condensed in providing the difference, between the heat represented by work done during expansion, and the heat which corresponds to the change of volume, and to the large quantity of work done during expansion at high pressure per unit of difference in the heat required to raise from a high to a higher pressure. H. W. S.

THE READING RAILROAD TERMINAL.—It is proposed by a syndicate of

public-spirited citizens to increase the facilities of travel to the country and suburban districts, tributary to the Reading Railroad system, by extending the line on an elevated arcade, similar to that of the Pennsylvania Company. The right of way has been purchased in fee, and the Company now awaits the action of City Councils, before beginning the construction of the proposed station at Twelfth and Market Streets. This project has disturbed the equanimity of the peaceful and quiet-loving community of Friends residing on Arch Street, which the line crosses, and has also excited the opposition of other interests, which, it is supposed, may be injured by the new line, so that we find history repeating itself, and the battle for progress being contested as warmly as ever.

The trite maxim of "the greatest good to the greatest number," as well as the increased revenue due to increased values, the great saving of time to the thousands whose homes must, of necessity, be remote from business and school, the four-fold greater area which becomes available by doubling the velocity of travel, are either overlooked, unknown, or overclouded by the personal interests which may destroy all patriotism and public spirit, and which would, if possible, reduce Philadelphia to the provincial "greene country towne," designed by its founders. This line will open up and render much more accessible over thirty-one miles of railroad within the city limits, developing one of the most beautiful and healthful sections for residences to be found in the vicinity of the city.

As to the method adopted by the Terminal Company, of securing its object by the purchase of property and the construction of an elevated way, it appears to be a question of relative cost and damages, which the Company have decided in favor of this plan, for this route. We think the interests of the city would have been better served had the Company joined issue with the recently chartered underground company, and thus have connected its lines with every part of the city, instead of with a single point, and at less expense.

That the expense would be less is shown by the fact that the estimate for elevating the trackways of the Reading Railroad system for a distance of five and five-sixteenths ($5\frac{5}{16}$) miles, so as to give the Company the same facilities as at present, is placed at \$12,750,000, or about \$2,400,000 per mile. This includes terminals, but excludes the proposed extension from Ninth and Green to Twelfth and Market, and the purchase of right of way. The proposed underground way was estimated at about \$1,056,000 per mile. Z.

CHEMISTRY.

ANIMAL CHLOROPHYL.—In the *Journal of Physiology*, for March, 1888, Prof. C. A. MacMunn reports studies on the chromatology of British sponges. The value of the paper to the general reader is the recorded similarity of the lipochromes, floridines, and uranidines of sea-water sponges to the chlorophyl of plants.

Out of twelve species of sponge examined by Prof. MacMunn, ten contained chlorophyl; adding to these seven sponges studied by Krukenberg,

we have seventeen sponges proven to contain chlorophyl by means of spectroscopic examination and chemical reagents. With regard to this chlorophyl, our author says: "I have no hesitation in saying that no difference worth mentioning was observed between it and vegetable chlorophyl." Chemical reactions proved it to be of purely animal origin; marine algæ are often to be found growing into the sponge substance, but great care was taken in these experiments to select portions in which, even when examined microscopically, with powers up to 1,250 diameters, no vegetable growth appeared. Prof. MacMunn does not think it necessary that the co-existence of starch with chlorophyl should be demonstrated in order to prove the presence of animal chlorophyl. Even in plants it is not always possible directly to observe starch as the product of assimilation in the chlorophyl grains; in such cases the starch produced in the chlorophyl may be at once transformed into fat.

If chlorophyl is present in sponges, the question arises, of what use is it to them? It cannot be of use for mere surface coloration, as its tint is, in most cases, disguised by yellow, red, or other color, and it must, therefore, be of use, either for purposes of assimilation, as in plants, or for respiration. Since chlorophyl is usually much more apparent in the external parts of the sponge, it is likely that it has something to do with the absorption of light rays. Prof. MacMunn "cannot help thinking that the very peculiar absorption spectrum of chlorophyl indicates a property which is peculiar to it, and which enables it to sift out rays of a certain wave-length to be utilized in the synthesis of the carbohydrates." The latest researches suggest that chlorophyl may be a respiratory pigment, and all recent botanical knowledge tends to explain its function as that of a carbonic acid carrier. It may primarily remove the waste CO_2 , and afterwards, by the influence of light rays, build up from CO_2 and from water, some substances, such as starch, glycogen, sugar, or fat, which are of direct service to the animal or plant. If this is its function, chlorophyl may be of great use in the constructive metabolism of animals. R. L. B.

A NEW METHOD OF PREPARING SILICON.—H. W. Warren (*Chem. News*, **57**, 54) suspends small bars of ferro-silicon immersed in dilute sulphuric acid from the positive pole of a battery, and resting upon a platinum plate that forms the negative pole. After solution of the iron, the residue consists of graphite, silica and amorphous silicon; this residue is heated to redness in carbon dioxide, and then to bright redness in a closed iron tube with zinc. The silicon is dissolved by the zinc, and is obtained in crystals when the zinc is treated with hydrochloric acid. If aluminium be used instead of zinc, and the temperature raised to whiteness, graphitoidal silicon is obtained.

W. H. G.

ON THE PREPARATION AND PROPERTIES OF NITROGEN CHLORIDE.—Victor Meyer has recently described (*Berl. Ber.*, **21**, 26) a method for the demonstration of the explosive properties of nitrogen chloride as a lecture experiment, the compound being prepared in a double-walled case of thick glass. Still more recently, Dr. Ludwig Gattermann (*loc. cit.* 751) has been

able, by following Meyer's method of operation and adopting special precautions for personal protection, to investigate more closely than had ever before been attempted, the properties of this unstable substance. Before these experiments no effort had been made to analyze nitrogen chloride, analysis having been limited to a determination of the ratio between the chlorine and nitrogen.

The compound was prepared by the reaction of chlorine and solution of ammonium chloride, and it is to be noticed that no oily drops appeared until more than half the chlorine (in a flask about one litre) had been absorbed. Very small globules then appeared, formed a film over the surface, and the film broke up into large drops, some of which sank, but were carried up and down in the liquid by a slow disengagement of nitrogen, owing to gradual decomposition. The drops were shaken down into a small lead capsule under the mouth of the flask, this capsule itself being placed in a large lead capsule that at first contained the solution of ammonium chloride. The small dish, with its contents, was carefully removed from the larger one, and the liquid poured through a funnel into a thin-walled separating funnel made for the purpose. The success of this operation showed that the explosive properties of nitrogen chloride have been exaggerated, for the liquid fell through more than two decimetres, experiencing considerable friction. The solution of ammonium chloride was removed by a pipette, and the oily liquid repeatedly shaken with water until the washings would give no chlorine reaction. The wash water must not be drawn into the caoutchouc bulb used to suck it up into the pipette, nor must it be allowed to come in contact with organic matter on running from the pipette, for it always contains small suspended globules of nitrogen chloride. Dissolved chlorine was removed by repeatedly blowing air through the liquid by the aid of a glass tube, so that the oily liquid was broken up into small drops and disseminated in the water. The nitrogen chloride never exploded in this operation.

It was then run off into a small glass flask, and this part of the operation is the most dangerous, on account of the friction of the stop-cock; in several experiments explosions took place at this stage. After the separation a small flask must at once be put under the end of the funnel that no drops may fall on the table. The nitrogen chloride was now dried by shaking with a small piece of fused calcium chloride free from dust, poured into a weighed cylindrical flask containing about one c.c. and provided with a not quite air-tight glass stopper. It was then weighed, the balance being placed in the glass case. The last-described operations are the most unpleasant, on account of the extremely irritating action of the vapor of nitrogen chloride on the eyes and mucous membranes.

The opened flask and its stopper were then quickly dropped into a bottle containing water, and the nitrogen chloride decomposed by ammonia which was gradually added. The chlorine was estimated as silver chloride.

The results showed that the product of the action of chlorine on ammonium chloride is not a uniform substance, but a varying mixture of several chlorinated ammonias; the longer the time of action of chlorine the more nitrogen trichloride is formed.

Pure *nitrogen trichloride* was prepared by passing chlorine through the product in the separating funnel after the ammonium chloride had been washed out, the drying and analysis being conducted as before.

Nitrogen chloride is exploded by the action of direct sunlight, and was in one case exploded by the light of burning magnesium. The author met with no explosions that could not be accounted for, and believes that previously reported spontaneous explosions of nitrogen chloride were occasioned by light.

The action of heat was studied by heating about half a gramme of the substance in a thin-walled tube immersed in fluid vaselin, the phenomena being observed from a distance of about five m. by the aid of a telescope. Up to 90°, no change occurred, but at 95° the apparatus was entirely destroyed by a violent explosion.

The author has prepared nitrogen chloride for these experiments about thirty times, and on account of the irritating nature of the vapors and the nervous strain of prolonged experiments where an explosion may occur at any moment, and which demand an extraordinary number of precautions, has postponed further work for a short time, hoping to eventually study the chemical properties of this interesting compound. W. H. G.

COMPOSITION OF BRONZE OF JAPANESE MAGIC MIRRORS.—Specimens of metal from three of the so-called Japanese mirrors, which came into the writer's possession, were examined under the direction of Dr. Geo. A. Koenig, of the University of Pennsylvania. The results are given in appended tabulation.

The composition of these bronzes varies to such an extent that it is manifest that they are not made according to any fixed formula. Each metal-worker evidently using his own recipe.

No. 1. J. E. Hawkins.	No. 2. M. H. Pugh.	No. 3. Geo. A. Koenig.	
Cu = 79'618	72'64	89'24	
Pb = 12'941	14'71	7'25	
Sn = 4'37 (by diff.)	8'52	. . .	
As = 2'531	2'94	3'03	
S = . . .	. . .	0'22	
Fe = 0'540	0'12	0'23	
100'000	98'93	99'97	W.

MISCELLANEOUS.

THE Universal Exposition of 1889, at Paris, promises to be one of the largest and most successful of the world's fairs held in recent years. Elaborate arrangements for the reception and display of the exhibits are well under way, and unusual facilities, both for the transportation of goods from this country and their care, are assured. The French government extended a formal invitation to the United States to take part in the Exposition. The invitation was accepted by a joint resolution of the Senate and House of Representatives, and the governors of the several states and territories were requested to invite the people to assist in the proper representation of the

products of American industry and of the natural resources of the country. The President was directed to appoint a commissioner-general and an assistant commissioner-general to make all of the arrangements for exhibits and represent the Government at the Exposition. He was also directed to appoint nine scientific experts as assistants to the Commission, each to be assigned to one of the nine groups into which the exhibits will be divided. Provision was made for the salaries of the commissioners and the necessary assistants, and the sum of \$250,000 was appropriated to be used under the direction of the Secretary of State to defray all expenses. The action of Congress was approved May 10th, and the President has appointed General William B. Franklin, Commissioner-General, and Mr. Somerville P. Tuck, Assistant Commissioner-General.

The commissioners have established their headquarters in the Mills Building, New York, and are busily engaged receiving applications and perfecting the details for a complete representation. The Exposition will open May 5th and close October 31, 1889, and there will be no charge for space occupied by exhibitors. The Commission will forward and return all articles received free of freight charges.

Goods of exhibitors who are unable to go to Paris or send representatives will be cared for free of all expense, except that of unpacking and repacking. There will be no duties to pay except on goods that are sold or consumed. The French regulations state that all objects exhibited will be protected against piracy of inventions or designs.

The exhibition is to be divided into nine groups or departments as follows :

- (1) Works of art.
- (2) Education and processes used therein.
- (3) Plain and decorative house furniture.
- (4) Textile fabrics.
- (5) The raw and manufactured products of mining, forestry, chemistry, etc.
- (6) Apparatus and methods of mechanical industries.
- (7) Food products.
- (8) Agriculture, vine culture and fish culture.
- (9) Horticulture.

The French government has appropriated 43,000,000 francs toward the expense of the Exposition. An advisory commission, consisting of 300 members, and styled the "Grand Council of the World's Exhibition of 1889," has been appointed. The Minister of Commerce and Manufactures acts as president of this council and also as commissioner-general of the Exhibition. The grand council is divided into twenty-two advisory committees, who have charge of the different departments and the management of the Exposition.

The buildings for the Exposition are now nearly completed. They occupy the Champ-de-Mars and the Trocadero Palace and Park on the banks of the Seine. In the park, at the entrance to the exhibition on the Champ-de-Mars, the wonderful Eiffel Tower is now in course of erection. It is to be entirely

of iron and 1,000 feet in height. Its object is to show the triumph of modern engineering skill. It will be furnished with an elevator of American manufacture. On the right of the tower is the Palace of Liberal Arts, and on the left the fine Palace of Fine Arts. Large gardens occupy the centre of the square, and at the back is the main building, or the Gallery of Machines as it is called. The Esplanade des Invalides is reserved for the products of the French colonies. The buildings are magnificent structures of glass and iron, lighted by electricity, and fitted with every modern convenience.

It is expected that the total number of exhibitors from all countries will reach 30,000; it is estimated that 12,000,000 persons will enter the grounds and buildings. Some idea of the magnitude of the exhibition may be gained from the fact that the total area of buildings and enclosed grounds, which is to be lighted by electricity, is 3,000,000 square feet. The space allotted to the United States is about 75,000 square feet. An exhibit from this country fully equal to that of 1878 is expected, and it is hoped that it will be much larger. There are numerous lines of industry that need new markets for their goods, and this exhibition will afford them an opportunity for foreign display.

All of the European countries, except Germany, take an interest in the Exposition, and will make displays. The South American republics and Mexico will also take a particularly active part, as well as Japan.

The usual awards of medals and diplomas will be made, but the details as to this have not yet been determined. W.

PRODUCTION OF INDIGO IN CHINA (*Jour. Soc. Arts, May 4, 1888*).—According to the report of British Consul Jones, of Chin Kiang, the indigo plant is cultivated as part of the crop of every farmer in that province, and after its manufacture into the dye is employed by his family for dyeing the cotton goods used for the clothing of his people. That which is not so consumed is put upon the market for sale and exportation.

As in the cultivation of rice, the seed of the indigo plant is sown in patches of ground, and as thickly as possible. In a month, when the plants are several inches high, they are transplanted into a large piece of ground, and in rows about eighteen inches apart. When they reach a height of about two feet, and the leaves have assumed a dark, rich blue color, they are cut to the ground, and gathered for the manufacturing process.

From the roots, when the plants are cut down, another growth springs up, and two crops are obtained in the year. In every farm there are a dozen or more large earthen jars or kongs, with the capacity of a barrel, which are used for the manufacture of indigo. Those who engage extensively in the manufacture have a large brick-lined tank built in the ground, six or eight feet in depth, and of a diameter of ten or fifteen feet, with a capacity of many hundred gallons. The plants are placed in these receptacles, and covered with clear, fresh water, where they are allowed to lie for several days till the indican is decomposed by fermentation. This process is aided by the addition of a little slaked lime and frequent stirring, when the indigo is precipitated in the form of a dark blue sediment, which, when dried, forms the indigo of commerce. H. T.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

- Argentine Republic. Message of the President on opening the session of the Argentine Congress. From the President.
- Armstrong on Steam-Engine Boilers. From Mr. Enoch Lewis.
- Ball Electric Light Company. Announcement, etc. From the Company.
- Bureau of Statistics. Quarterly Report of the Chief, No. 4. 1887-1888.
From the Bureau.
- Commissioner of Labor. United States. Third Annual Report, 1887.
From the Commissioner.
- Connoisseur, The. Vol. 1, 1887. From Bailey, Banks & Biddle.
- Cooper, J. H. One Rule for All. (Reprint Manufacturer and Builder.)
From the Author.
- Department of Agriculture. Periodical Bulletin. Vol. 1, No. 4.
Report of the Statistician, No. 56. From the Department.
- Diagram showing evaporative Power of American Coals as determined in the years 1878 to 1882, at the Quartermaster's Department, Washington.
From Gen. M. C. Meigs.
- Holmes, G. Science of voice Production and voice Preservation.
From Dr. Isaac Norris.
- Hydrographic Office. Pilot Chart of the North Atlantic Ocean. November, 1888.
From the Office.
- Journal of Analytical Chemistry. Vol. 1. 1887. From the Editors.
- Lightning Flash. Two photographs. From Mr. W. N. Jennings.
- Massachusetts State Agricultural Experiment Station. Bulletin No. 31.
From the Station.
- Meteorological Office. London. Weekly Weather Report, May 14th to September 24th.
From the Office.
- Meteorological Service of the Dominion of Canada. Report for 1885.
From the Superintendent.
- Mercantile Library of Philadelphia. Bulletin No. 25. Vol. 1.
From the Library.
- Montreal Water Works. Annual Report of the Superintendent for 1887.
From the Works.
- New York Academy of Sciences. Transactions, Nos. 7 and 8. Vol. 7. Annals, No. 8. Vol. 4.
From the Academy.
- Nova Scotian Institute of Natural Science. Proceedings and Transactions. Vol. 7. Part 2.
From the Institute.
- Oliver, Chas. A. A description of a Case of Coloboma of the Iris.
From the Author.
- Patent Office U. S. Specifications and Drawings. July, 1887.
From the Office.
- Peale, A. C. Classification of American Mineral Waters.
From the Author.
- Pennsylvania Academy of the Fine Arts. Circular of the Committee on Instruction. 1888-9.
From the Committee.

Public Documents United States.

Senate Executive Documents. Vols. 4 to 7.

Senate Miscellaneous Documents. Vols. 2, 3, 7 and 8.

House Executive Documents. Vols. 13, 18, 22, 24, 29, 32, 34 and 37.

House Miscellaneous Documents. Vols. 8, 10, 11, 14, 18, 19, 21 and 26.

From the Department of the Interior.

Quimby, W. Ophir.

From the Author.

Seafert System of Generating Electrical Energy.

From William Seafert & Co.

Semaphore Signals. Two photographs.

From Prof. C. H. Koyl.

Schley, Winfield S. Report of. Commanding the Greely Relief Expedition.

From Secretary of the Navy.

Signal Office U. S. Daily International Chart. September, 1887. Summary
and Review. September, 1887.

From the Office.

Smiley, Charles W. Altruism Considered Economically.

From the Author.

Taylor, Frank H. Autumn Leaves upon the Lehigh.

From Mr. S. H. Needles.

United States Geological Survey. Twenty United States Atlas Sheets.

From the Survey.

University of Pennsylvania. The Muybridge Work.

From the University.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, November 21, 1888.*]

HALL OF THE INSTITUTE, PHILADELPHIA, November 21, 1888.

Mr. CHAS. BULLOCK, Vice-President, in the Chair.

Present, 135 members and thirty-three visitors.

Additions to membership since previous meeting, seventeen.

Mr. SAMUEL SARTAIN, Treasurer, reported the gift of an additional \$5,000 from Mrs. CLARA JESSUP BLOOMFIELD MOORE, to the BLOOMFIELD H. MOORE trust fund for the endowment of the Library. The trust was accepted and the thanks of the INSTITUTE were ordered to be transmitted to the giver.

The following papers were read in the order named below, viz :

"A Substitute for Glass as a Support for Gelatine Bromide of Silver in Photography," by JOHN CARBUTT.

"The Parabolic Semaphore; an Improved Railroad Signal," by Prof. C. HERSHEL KOYL.

"Heliochromy." Further contributions to Photography in Natural Colors, by FRED. E. IVES.

The papers were referred to the Committee on Publications.

On Mr. G. M. ELDRIDGE's motion, the subject of Prof. KOYL's paper was referred to the Committee on Science and the Arts, for further investigation.

The Secretary presented his usual monthly report, in the course of which he exhibited an elevation and plans of a new building for the INSTITUTE, designed by JOS. M. WILSON, architect, and President of the INSTITUTE.

Adjourned.

WM. H. WAHL, *Secretary*.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JULY, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE

PHILADELPHIA, July 31, 1888.

TEMPERATURE.

The mean temperature for July, determined from the tri-daily observations, was $69^{\circ}.4$, and from the mean maximums and mean minimums, $69^{\circ}.2$.

These are about 3° below the normal. At Philadelphia, the monthly deficiency of temperature was 124° , and at Pittsburgh, 113° .

The highest temperatures did not reach the average maximums by a few degrees, and the minimums ranged about 4° below those generally recorded in July.

The extremes reported were, Charlesville, 97°; Carlisle, 96°; Huntingdon, 94°·5; Somerset, 94°·5; Quakertown, 94°; Philadelphia, 93°·8; York, 93°·5; Chambersburg, 93°·5; Reading, 93°·5, the highest; and Coudersport, 38°; Dyberry, 39°; Smethport, 39°; Wellsboro, 40°; Honesdale, 41°; New Castle, 41°; and Wysox, 41°, the lowest.

Most of the high temperatures occurred on the 4th and 7th, and the lowest on the 13th, 14th and 16th. The nights were generally cool.

· ATMOSPHERIC PRESSURE.

The barometer averaged nearly ·10 above the normal, with a range of about ·50.

PRECIPITATION.

There was an average of 3·45 inches of rainfall, which is from half to three quarters of an inch below the normal. It was fairly well distributed, although a few stations report decided departures from the average. The greatest totals were, Uniontown, 7·10 inches; Indiana, 7·04 inches; Beaver, 5·18 inches; New Castle, 4·90 inches, and Lock Haven, 4·75 inches. The least were, Coudersport, 1·40 inches; Smethport, 1·40 inches; Drifton, 2·16 inches, and Emporium, 2·17 inches.

The heaviest amounts fell on the 8th, 9th, 18th, 19th and 27th. It was seasonably distributed throughout the month, and there were few complaints from drouth.

WIND AND WEATHER.

No heavy wind-storm passed over the state, and there were not the usual number of severe local wind storms and damages by lightning usually reported. But few hail-storms occurred. The weather was favorable for harvesting, and large hay and wheat crops were garnered in excellent condition. Farmers report the season as being unusually productive.

Average number.—Rainy days, 8; clear days, 15; fair days, 10; cloudy days, 6.

MISCELLANEOUS PHENOMENA.

Thunder-Storms.—Beaver, 24th; Charlesville, 23d, 27th; Reading, 5th, 12th, 24th; Hollidaysburg, 4th, 5th, 8th, 12th, 18th, 19th, 20th, 27th; Quakertown, 5th, 20th, 24th, 27th; Johnstown, 4th, 5th, 8th, 12th, 19th, 23d; State College, 19th; West Chester, 5th, 20th; Coatesville, 5th, 7th, 20th; Grampian Hills, 5th, 19th; Lock Haven, 9th, 18th, 19th, 27th; Catawissa, 5th, 8th, 9th, 19th, 27th, 29th; Carlisle, 20th, 27th; Uniontown, 8th, 12th, 23d; Indiana, 12th, 18th, 19th, 24th, 27th; Lancaster, 9th, 10th, 12th, 20th, 27th, 28th; New Castle, 26th; Lebanon, 27th; Drifton, 27th; Stroudsburg, 27th, 31st; Pottstown, 5th; Bethlehem, 5th; Shamokin, 5th, 12th, 27th; New Bloomfield, 27th; Philadelphia, 5th, 19th, 27th; Somerset, 4th, 5th, 8th, 19th, 23d, 27th; Eagles Mere, 5th, 20th; Wellsboro, 5th, 11th, 18th, 27th, 29th, 31st; Franklin, 11th, 17th, 19th, 31st. Dyberry, 5th, 11th, 12th, 19th, 27th, 30th, 31st; York, 27th.

Hail Storms.—Charlesville, 27th; Grampian Hills, 19th; Eagles Mere, 20th.

Frosts.—Somerset, 2d; Wellsboro, 13th, 14th, 16th.

Auroras.—Eagles Mere, 28th.

Solar Halos.—Wellsboro, 8th, 31st; Eagles Mere, 11th.

Lunar Halos.—Somerset, 17th.

Coronæ.—Indiana, 16th, Lebanon, 20th, Eagles Mere, 15th.

T. F. T

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhardt, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.

<i>Displayman.</i>	<i>Station.</i>
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.

ER SERVICE FOR JULY, 1888.

PRECIPITATION.		NUMBER OF DAYS.			WIND.			OBSERVERS.
Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.			
					7 A. M.	2 P. M.	9 P. M.	
4.36	11	7	17	7	NW	NW	NW	Oscar D. Stewart, Sgt. Sig. Corps.
5.18	8	...	...	...	...	...	...	Smith Curtis.
3.99	10	...	...	...	...	...	...	Rev. A. Thos. G. Apple.
2.50	10	15	11	5	NW	NW	SW	C. M. Dechant, C.E.
...	...	...	...	...	...	...	...	Prof. J. H. Rohrbach.
2.73	10	...	...	...	...	...	...	Dr. Charles B. Dudley.
3.73	9	15	11	5	W	W	W	Prof. J. A. Stewart.
2.31	7	15	6	10	NW	S	S	Charles Beecher.
3.44	11	17	7	7	NW	W	NE	J. L. Heacock.
...	...	...	...	...	...	...	...	J. E. Forsythe.
4.33	11	16	10	5	SW	SW	SW	E. C. Lorentz.
2.17	7	...	...	...	W	W	W	T. B. Lloyd.
2.78	6	11	15	5	W	W	W	Prof. Wm. Frear.
4.13	10	22	5	4	SW	SW	SW	L. Ray Morgan.
4.47	13	21	6	4	N	NW	S	Jesse C. Green, D.D.S.
3.91	9	18	7	6	W	W	W	W. T. Gordon.
...	...	...	...	...	...	...	...	Rev. W. W. Deatrick, A.M.
3.66	10	9	11	11	NW	W	SW	C. M. Thomas, B.S.
4.75	7	20	9	2	W	W	W	Nathan Moore.
2.48	10	15	9	7	S	W	S	Prof. John A. Robb.
...	...	...	...	...	...	...	...	Robert M. Graham.
3.43	10	17	8	6	NW	W	W	Prof. J. H. Montgomery.
3.27	8	8	10	13	W	W	W	J. E. Pague.
2.94	8	9	11	11	NW	NW	...	Frank Ridgway, Sgt. Sig. Corps.
3.17	10	...	...	...	NW	NW	NW	Prof. Susan J. Cunningham.
7.10	8	21	7	3	SW	SW	SW	Joe Messinger.
...	...	...	...	...	...	...	...	Peter Wood, Sgt. Sig. Corps.
2.90	5	...	...	...	...	...	...	Wm. Hunt.
2.68	8	15	10	6	o	W	W	Robert L. Haslet.
3.61	6	...	...	...	...	...	...	Miss Mary A. Ricker.
7.04	11	13	13	5	SW	SW	SW	Thomas F. Sloan.
...	...	...	...	...	...	...	...	Prof. W. J. Swigart.
4.12	7	9	15	7	N	W	W	Prof. Albert E. Maltby.
4.90	9	11	13	7	SE	N	NE	T. F. Heebner, M.D.
2.50	9	19	8	4	NE	SW	SW	A. M. Schmidt, A.B.
2.16	5	...	...	...	NW	NW	NW	Wm. T. Butz.
1.41	9	16	9	6	S	SW	SW	George W. Hayes, C.E., Ph.G.
3.95	7	11	15	5	N	NW	N	H. D. Miller, M.D.
3.44	5	15	9	4	W	W	SW	E. H. Baker.
3.31	9	22	5	4	W	W	W	Armstrong & Brownell.
2.73	8	23	4	4	W	W	W	Prof. S. H. Miller.
2.47	6	13	8	5	NW	S	S	N. C. Miller, M.D.
2.47	4	22	5	4	W	N	W	Charles Moore, D.D.S.
3.38	10	12	8	11	SW	NW	NW	Lerch & Rice.
1.40	5	23	3	5	NW	NW	...	G. R. Hanley.
3.34	0	16	8	7	NW	NW	NW	Frank Mortimer.
4.10	11	18	5	9	SW	SW	NW	Luther M. Dey, Sgt. Sig. Corps.
3.02	11	8	16	7	NW	SW	NW	C. L. Peck.
2.38	9	15	5	11	NW	NW	NW	E. C. Wagner.
3.50	10	12	14	5	N	N	N	J. M. Boyer.
2.77	7	8	19	4	NW	NW	NW	W. M. Schrock.
...	...	...	...	...	...	...	...	E. S. Chase.
2.61	12	14	15	2	SW	SW	W	C. R. Claghorn.
4.19	0	15	11	5	W	W	W	A. H. Berlin.
1.75	7	...	...	...	...	...	...	H. D. Deming.
2.84	7	20	6	5	NW	NW	NW	Prof. N. P. Kinsley.

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR JULY, 1888.

COUNTY.	STATION.	Elevation above Sea Level (feet).	BAROMETER.			TEMPERATURE.										PRECIPITATION.			NUMBER OF DAYS.			WIND.			OBSERVERS.					
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	DAILY RANGE.						Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.								
											Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.						Date.	7 A. M.	2 P. M.		9 P. M.				
Allegheny	Pittsburgh.	847	30.018	30.190	29.780	71.7	90.1	4	50.5	11	82.4	62.4	20.0	27.1	25	6.3	9	66.4	59.2	4.36	11	7	17	7	NW	NW	NW	Oscar D. Stewart, Sgt. Sig. Corps.		
Beaver	Beaver.	791	30.118	30.190	29.780	68.6	89.0	31	51.0	14	81.3	60.8	18.8	27.0	17.31	10	13	77.1	63.0	5.18	8	..	..	..	..	..	..	..	Smith Curtis.	
Bedford	Charlestown.	1,300	30.118	30.190	29.780	67.8	97.0	4	44.0	2	81.0	54.6	26.4	36.0	25	10.0	13	84.6	63.4	3.99	10	..	..	..	..	..	..	..	Rev. A. Thos. G. Apple.	
Berks	Reading.	304	30.218	30.195	29.710	72.0	93.5	5	43.0	2	83.9	58.8	25.1	40.0	2	10.2	18	76.2	63.4	2.50	10	15	11	5	..	NW	NW	NW	C. M. Dechant, C.E.	
Blair	Keystone State Normal School.	549	30.281	30.281	29.713	89.0	4.8	50.0	13	81.7	60.6	21.3	28.0	4	14.0	10.31	38.2	55.0	2.73	10	..	..	..	..	..	..	..	..	..	Prof. J. H. Rohrbach.
Blair	Altoona.	1,181	30.281	30.281	29.713	89.0	4.8	50.0	13	81.7	60.6	21.3	28.0	4	14.0	10.31	38.2	55.0	2.73	10	..	..	..	..	..	..	..	..	..	Dr. Charles B. Dudley.
Bradford	Hollidaysburg.	947	30.281	30.281	29.713	89.0	4.8	50.0	13	81.7	60.6	21.3	28.0	4	14.0	10.31	38.2	55.0	2.73	10	..	..	..	..	..	..	..	..	..	Prof. J. A. Stewart.
Butler	Wysox.	718	30.000	30.240	29.740	68.7	90.8	31	41.0	16	80.8	53.6	27.0	39.0	10	15.5	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	Charles Beecher.		
Butler	Quakertown.	536	30.000	30.240	29.740	68.7	90.8	31	41.0	16	80.8	53.6	27.0	39.0	10	15.5	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	J. L. Heacock.		
Butler	Butler.	536	30.000	30.240	29.740	68.7	90.8	31	41.0	16	80.8	53.6	27.0	39.0	10	15.5	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	J. E. Forsythe.		
Cambria	Johnstown.	1,184	29.937	30.070	29.780	67.8	92.0	4	48.0	14	84.3	57.3	27.0	40.0	3	9.0	9	74.4	60.1	4.33	11	10	10	5	SW	SW	SW	E. C. Lorenz.		
Cameron	Emporium.	1,039	30.020	30.240	29.740	68.7	92.0	4	48.0	14	84.3	57.3	27.0	40.0	3	9.0	9	74.4	60.1	4.33	11	10	10	5	SW	SW	SW	T. B. Lloyd.		
Centre	State College.	1,191	30.035	30.085	29.612	69.2	86.0	4	45.0	13	78.0	55.6	22.4	31.0	23.25	8.0	18	73.3	61.0	2.98	6	11	15	5	W	W	W	Prof. Wm. Frear.		
Centre	Agricultural Experiment Station.	1,191	30.035	30.085	29.612	69.2	86.0	4	45.0	13	78.0	55.6	22.4	31.0	23.25	8.0	18	73.3	61.0	2.98	6	11	15	5	W	W	W	L. Ray Morgan.		
Chester	Phillipsburg.	1,191	30.035	30.085	29.612	69.2	86.0	4	45.0	13	78.0	55.6	22.4	31.0	23.25	8.0	18	73.3	61.0	2.98	6	11	15	5	W	W	W	Prof. Wm. Frear.		
Chester	West Chester.	1,191	30.035	30.085	29.612	69.2	86.0	4	45.0	13	78.0	55.6	22.4	31.0	23.25	8.0	18	73.3	61.0	2.98	6	11	15	5	W	W	W	Jesse C. Green, D.D.S.		
Chester	Coatesville.	1,191	30.035	30.085	29.612	69.2	86.0	4	45.0	13	78.0	55.6	22.4	31.0	23.25	8.0	18	73.3	61.0	2.98	6	11	15	5	W	W	W	Rev. W. W. Deatrick, A.M.		
Clarion	Emerysburg.	1,500	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Clarion	Kimberburg.	1,500	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Clarion	Clarion.	1,500	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Clearfield	State Normal School.	1,530	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Clearfield	Greentown Hill.	1,530	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Cletope	Lock Haven.	560	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Columbia	Catawissa.	494	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Columbia	Meadville.	494	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Cumberland	Allegheny College.	1,090	30.024	30.024	29.662	70.8	93.5	7	50.0	13	80.1	61.8	18.3	24.0	3	11.0	9	68.0	60.0	4.47	13	21	6	4	N	NW	NW	..		
Dauphin	Harrisburg.	480	30.040	30.230	29.680	71.5	91.4	7	54.0	5	81.5	63.0	18.5	29.0	4	6.0	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Delaware	Swarthmore.	190	30.017	30.213	29.665	71.3	91.9	7	53.4	13	83.1	61.0	18.1	26.2	3	11.4	29	71.0	61.0	2.94	8	9	11	11	NW	NW	NW	..		
Elk	Ridgway.	190	30.017	30.213	29.665	71.3	91.9	7	53.4	13	83.1	61.0	18.1	26.2	3	11.4	29	71.0	61.0	2.94	8	9	11	11	NW	NW	NW	..		
Elk	Elk.	681	30.020	30.200	29.700	70.0	87.0	4	52.0	12	76.0	60.7	16.2	26.0	3	6.0	9	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Eric	Uniontown.	1,000	30.017	30.244	29.724	70.3	91.4	7	54.0	5	81.5	63.0	18.5	29.0	4	6.0	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Fayette	Tioga.	1,058	30.017	30.244	29.724	70.3	91.4	7	54.0	5	81.5	63.0	18.5	29.0	4	6.0	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Forest	Chambersburg.	618	30.108	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Franklin	McConnellsburg.	375	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Fulton	Huntingdon.	690	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Huntingdon	Huntingdon.	690	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Indiana	The Normal College.	1,350	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Indiana	Indiana.	1,350	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Lackawanna	State Normal School.	1,350	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Lackawanna	Scranton.	750	30.024	30.447	29.766	69.7	93.5	7	47.0	2	83.5	57.8	25.7	36.5	25	13.0	9	80.9	64.2	2.90	8	15	10	6	W	W	W	..		
Lancaster	Lancaster.	413	30.024	30.230	29.701	72.2	92.0	7	57.0	13	82.5	63.0	18.5	29.0	4	6.0	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Lawrence	Franklin and Marshall College.	932	30.024	30.230	29.701	72.2	92.0	7	57.0	13	82.5	63.0	18.5	29.0	4	6.0	1	71.1	59.1	2.31	7	15	6	10	NW	NW	NW	..		
Lebanon	New Castle.	480	30.005	30.271	29.686	70.0	90.8	7	47.0	2	82.2	57.9	24.3	33.6	25	10.7	3	81.4	64.1	2.50	9	19	8	6	W	W	W	..		
Lebanon	Lebanon.	480	30.005	30.271	29.686	70.0	90.8	7	47.0	2	82.2	57.9	24.3	33.6	25	10.7	3	81.4	64.1	2.50	9	19	8	6	W	W	W	..		
Luzerne	Drifted Hospital.	1,685	30.024	30.271	29.686	70.0	90.8	7	47.0	2	82.2	57.9	24.3	33.6	25	10.7	3	81.4	64.1	2.50	9	19	8	6	W	W	W	..		
Lycoming	Williamsport.	545	30.024	30.271	29.686	70.0	90.8	7	47.0	2	82.2	57.9	24.3	33.6	25	10.7	3	81.4	64.1	2.50	9	19	8	6</						

Eric	New Castle.	Beaver.	Pittsburgh.	West Chester.	Coatesville.	Dyberry.	Honesdale.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Stroudsburg.	Coudersport.	Schizholzville.	Frederick.	Otsville.	German town.	Smith's Corner.	Point Pleasant.	Doylestown.	Lansdale.	Forks of Neshaminy.
.	.	.	.	.	.	'04	'07	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	1'10	.	'24	.	.	.	.	'46	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	'21	.	'41	39	'90	'06	'24	.	'14	'09	'05	'23	.	'08	'16	.	'55	'25	'25	'10	'48	'18
'02	'08	'40	'49	.	'01	.	.	'25	'07	.	.	.	.	.	.	.	.	.	.	.	.	.
'02	1'00	1'13	1'04	07	'88	'12	'11	'39	'85	'44	1'00	.	'10	1'09	'70	'80	.	.	.	.	.	.
'02	.	.	'07	'91	'72	'08	'83	.	'18	1'29	'69	.	.	.	'42	.	1'41	'99	'98	1'15	1'08	'06
'38	1'10	'10	'42	1'60	'54	'05	.	'07	'00	.	'80	.	'20	'15	'17	.	'50	.	.	'07	.	'06
.	.	'58	'01	'04	.	.	.	.	'60	.	.	.	.	.	.	.	.	.	.	.	'15	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	'07	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	'12	.	.	.
1'01	'78	1'30	'16	.	.	.	.	.	.	'05	.	.	.	.	.	.	.	.	.	.	.	.
1'44	'23	'02	'40	07	'33	1'27	1'64	'46	'28	.	'29	'93	.	'39	'58	'49	'34	'38	.	.	'29	.
'04	.	.	'10	'27	.	.	.	'26	'20	.	.	'24	.	.	'18	.	'15	'11	'75	'48	1'35	'58
'02	.	.	'03	.	.	.	.	'01	.	.	.	.	.	.	.	.	.	.	.	'35	.	.
'15	'80	'06	.	.	.	.	.	'03	.	.	.	.	'30	.	'33	.	.	.	.	'05	'43	.
'14	'85	'85	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
'01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
'06	'20	.	'21	17	'12	'39	'63	'98	1'45	'10	'17	2'00	'35	'85	'45	1'01	'82	1'68	1'35	'10	'04	.
.	.	.	'03	'14	.	.	.	.	'04	'08	'34	'04	.	.	.	.	.	.	.	'60	'47	2'00
.	.	.	'01	.	.	.	.	.	'07	.	'01	.	.	.	.	.	'30	'11	.	'06	.	'00
.	.	.	'02	.	1'81	'23	.	.	.	.	.	.	.	.	.	.	'06	.	.	.	.	'00
.	.	.	'01	.	'37	'00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	'00
3'17	4'90	5'18	4'36	2'47	3'01	4'19	3'75	2'73	1'44	2'04	1'38	1'44	1'40	2'56	2'00	2'30	4'07	1'65	3'45	2'06	4'20	2'80

I. F. T.

PRECIPITATION FOR JULY, 1888.

[illegible]

T. F. T.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR AUGUST, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, August 31, 1888.

TEMPERATURE.

The mean monthly temperature, $69^{\circ}.5$, is about $2^{\circ}.3$ below the average. The greatest departures were in the western portions of the state. Philadelphia was exactly normal.

The temperature deficiencies, from January 1st to September 1st, were Erie, 723° ; Philadelphia, 326° , and Pittsburgh, 158° . The highest temperatures during the month occurred on the 4th, 8th and 16th, and were about the same as usually recorded. The coldest periods were the 23d, 28th and 29th, and the temperature ranged about 3° below that generally observed during August. The maximums were, Lock Haven, 100° ; Chambersburg, 98° ; New Bloomfield, 98° ; York, 98° ; Philadelphia, $97^{\circ}.5$; Catawissa, $97^{\circ}.5$; Reading, 97° ; Pottstown, 97° ; Shamokin, 97° , and Selins Grove, 97° . Minimums, Phillipsburg, 33° ; Somerset, 33° ; Wellsboro, 34° ; Bernice, 37° ; Greenville, $37^{\circ}.8$; Smethport, 38° ; Dyberry, 38° ; Charlesville, 38° , and Honesdale, 39° .

BAROMETER.

The atmospheric pressure was slightly above the normal. The highest was on the 10th and 11th, and the lowest, 29.40, occurred during the cyclonic storm of the 21st, the centre of which passed northeastward over Pennsylvania, and was accompanied by torrential rains, and followed by the coldest period of the month.

PRECIPITATION.

The rainfall for the month was phenomenal. Its average for the state was 7.05 inches, being nearly 3 inches more than the normal. The excess was largely due to the excessive fall on the 21st. The following totals were reported as having occurred during this storm: Girardville, 5.65 inches; Selins Grove, 5.20 inches; Kutztown, 5.07 inches; Huntingdon, 4.80 inches; Lebanon, 4.76 inches; New Bloomfield, 4.75 inches; Scisholtzville, 4.72 inches; Hollidaysburg, 4.72 inches; Uniontown, 4.53 inches; Reading, 4.52 inches; Somerset, 4.50 inches, and Johnstown, 4.49 inches.

Other heavy rainfalls occurred on the 12th and 17th. The largest monthly totals were, Drifton, 11.27 inches; Kutztown, 10.95 inches; Indiana, 10.65 inches; Uniontown, 10.23 inches, and Selins Grove, 10.12 inches.

WIND AND WEATHER.

The only severe storm during the month was on the 21st. The weather was generally favorable for agricultural pursuits. A few light frosts were reported. The corn crop promises to be a large one and the potato yield above the average.

Average number.—Rainy days, 10; clear days, 13; fair days, 10; cloudy days, 8. Prevailing wind, direction S. W.

MISCELLANEOUS PHENOMENA.

Thunder-Storms.—Pittsburgh, 12th; Charlesville, 4th, 5th, 8th, 11th, 12th, 16th, 27th; Reading, 4th, 12th, 16th, 27th; Kutztown, 4th, 5th, 8th, 12th, 16th; Hollidaysburg, 3d, 8th, 12th; Wysox, 16th, 17th; Quakertown, 4th, 8th, 12th, 17th; Johnstown, 4th, 5th, 8th, 12th, 16th, 27th; Emporium, 4th, 12th, 13th, 17th, 22d; State College, 12th; Phillipsburg, 12th, 17th; West Chester, 4th, 8th, 12th, 17th; Coatesville, 4th, 5th, 8th, 12th; Grampian Hills, 4th, 8th, 12th, 16th, 17th; Catawissa, 5th, 9th, 11th, 12th; Swarthmore, 5th, 6th, 12th, 27th, 31st; Uniontown, 4th, 12th, 17th, 18th, 27th; McConnellsburg, 12th, 27th; Indiana, 1st, 3d, 4th, 8th, 12th, 17th, 21st; New Castle, 4th, 7th, 12th, 16th; Lebanon, 4th, 8th, 12th; Smethport, 17th; Greenville, 3d, 4th, 6th, 7th, 12th, 16th; Pottstown, 8th, 12th; Bethlehem, 4th, 5th, 8th; Shamokin, 4th, 8th, 12th, 13th, 18th; New Bloomfield, 4th, 8th, 11th, 12th, 13th; Philadelphia, 4th, 5th, 8th, 12th, 27th; Girardville, 4th, 8th, 12th; Somerset, 4th, 8th, 12th, 17th, 18th; Eagles Mere, 12th, 16th; Bernice, 4th, 8th, 12th; Montrose, 8th, 13th; Wellsboro, 1st, 4th, 12th, 17th; Dyberry, 4th, 5th, 8th, 9th, 16th, 17th; York, 8th, 27th.

Hail-Storms.—Charlesville, 12th; Lock Haven, 8th; Uniontown, 12th; McConnellsburg, 12th.

Frosts.—Charlesville, 23d, 29th; Quakertown, 29th; Phillipsburg, 27th; Rimersburg, 23d, 27th; Grampian Hills, 28th, 29th; Tionesta, 23d, 27th, 28th; Greenville, 23d; Somerset, 23d, 28th, 29th; Wellsboro, 14th, 22d, 23d, 27th, 28th; Dyberry, 23d, 28th, 29th; York, 23d.

Coronæ.—Charlesville, 14th, 15th, 17th; Rimersburg, 14th; Indiana, 19th; Greenville, 19th; Somerset, 28th; Eagles Mere, 17th; Dyberry, 14th, 15th.

Halos.—Charlesville, 11th, 20th; Rimersburg, 18th; Indiana, 16th; Greenville, 17th; Girardville, 14th, 15th; Somerset, 15th, 16th, 17th; Eagles Mere, 16th; Wellsboro, 16th; Dyberry, 18th. T. F. T.

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhart, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm. A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.

<i>Displayman.</i>	<i>Station.</i>
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.

PREC

Relative Humidity.	Dew Point.	Total Inches.
Alleg ^{72°0}	60°9	7°26
Beaver ^{71°0}	64°0	6°92
Bedford ^{79°5}	60°5	7°02
Berks ^{88°9}	66°0	6°62
Berks		
Blair ^{80°5}		10°92
Blair ^{89°0}	66°0	5°36
Bradford ^{74°6}	63°6	7°26
Buck ^{83°9}	66°0	6°1
Butler		8°52
Cambridge ^{67°9}	60°8	
Cameron ^{71°0}	62°0	8°34
Centre		4°22
Centre ^{73°2}	61°4	6°14
Chest ^{80°0}	62°4	7°16
Chest		3°96
Clarke		4°26
Clarke		
Clear		8°11
Clinton		7°33
Colur		6°21
Craw		
Cumt		
Daup ⁵⁸	63°0	6°21
Delaw ^{4°0}	63°0	6°7
Elk		
Eric ^{79°0}	57°0	3°71
Faye ⁶⁴	62°2	10°2
Fores ⁹⁴	59°0	4°4
Frank		
Fulton ⁷⁶	64°2	5°4
Hunt	58°0	8°6
		8°5
India ⁹³	63°1	10°6
Lack		
Lanc		
Law ⁶⁰	65°3	6°3
Leban ⁷⁸	63°2	7°7
Laze		
		11°2
Lycor		
McK ⁷⁴	58°2	6°7
Merc ⁵⁶	64°5	4°1
Mont		
Mont ⁷⁰	66°1	6°1
North ⁷⁰	63°0	3°2
North ⁷⁰	61°0	6°5
Perry		7°0
Phil ⁷⁶	60°6	5°8
Pott ⁷⁰	55°0	4°2
Schu		6°5
Snyd		11°1
Som ⁷¹	61°1	7°6
Sull ⁷⁰	60°0	9°2
Sull ⁷⁰	57°6	6°2
Susp		7°8
Tiog ⁷⁸	61°2	5°7
Ven		
Was		
Was		
War ⁷⁰	56°0	3°1
Way		7°4
Way		5°2
West		
York ⁷³	63°7	5°0

low
ate.
low
lle,
im-
rry,
ese
nest
sle,
5;
en-

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR AUGUST, 1888.

COUNTY.	STATION.	Elevation above Sea Level (feet).	BAROMETER.			TEMPERATURE.										PRECIPITATION.		NUMBER OF DAYS.			WIND.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
			Mean.	Highest.	Lowest.	MAXIMUM.		MINIMUM.		DAILY RANGE.						Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
						Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.						Least.	Date.	7 A. M.	2 P. M.	9 P. M.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
																					RELATIVE HUMIDITY.						OTHERS.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

Erie.	Greenville.	New Castle.	Beaver.	Meadville.	Montrose.	Reading.	Kutztown.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Honesdale.
'42	'04	'86	'20	1'00	'39	.	'05	.	'14	'02	'22	'4.
'04	'05	'17	.	'63	'40	.	.	.	.	.	.	.
'30	'75	'46	.	.	'30	'63	1'07	.	.	.	'60	'25
.	'13	'25	'50	'84	'71	.	'39	'30	'04	'07	'60	'11
'12	'02	'21	.	'05	.	'14	.	.	'11	'00	'20	'86
'08	.	.	'15	'01	.	'25	'83	'30	.	'01	.	'23
.	.	.	.	'35	.	.	.	'35	'15	'52	'10	.
.	.	.	.	.	.	.	.	'10	'06	'20	.	.
'02	.	.	.	.	1'22	'52	1'09	'70	'60	'49	'60	1'78
'80	'92	1'37	'70	'15	'22	09	'35	'20	'14	'11	1'29	.
'04	.	.	.	'85	.	.	.	.	.	.	.	.
.	.	.	.	.	'90	.	'13	.	.	.	'13	'07
'01	.	.	.	.	1'38	'06	.	'08	'16	.	'51	'49
'64	1'09	2'50	2'20	'90	.	.	.	.	'10	'09	.	.
.	.	.	.	.	.	.	.	.	'09	'02	.	.
.	'18	'44	1'20	.	'06	4'52	5'07	3'80	1'57	2'14	1'19	1'34
.	.	.	.	'01	.	.	.	.	'10	'36	'24	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	'07	.	.	.	'04	.	.	'02	'03	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	1'40	'40	1'07	'49	'65	'22	'58	.
3'76	3'18	6'38	6'5	4'7	7'89	6'05	10'95	6'13	3'96	4'20	7'46	5'59

E.

of the

FE,
1888.

below
 sk late.
 ' below
 esville,
 Colum-
 berry,
 These
 highest
 arlisle,
 53°5 ;
 e gen-

PRECIPITATION FOR AUGUST, 1888.

[illegible]

T. F. T.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR SEPTEMBER, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 30, 1888.

TEMPERATURE.

The temperature for September, like that of July and August, was below the normal. At the end of the month, the season was about one week late.

The mean temperature $59^{\circ}0$, determined from fifty-two stations, is 2° below the average. The highest temperatures were, Emporium, 84° ; Coatesville, 84° ; McConnellsburg, 84° ; Lancaster, 84° ; New Bloomfield, 84° , and Columbus, 84° . These occurred on the 9th and 12th. The lowest were Dyberry, 29° ; Honesdale, 30° ; Somerset, 30° ; Bernice, 30° , and Columbus, 30° . These occurred on the 29th and 30th. The following stations report the highest mean monthly temperatures. Pottstown, $64^{\circ}3$; Coatesville, $64^{\circ}6$; Carlisle, $63^{\circ}7$, and Catawissa, $63^{\circ}5$. Lowest: Somerset, $53^{\circ}3$; Phillipsburg, $53^{\circ}5$; Bernice, $54^{\circ}9$; Dyberry, $54^{\circ}5$, and Smethport, $55^{\circ}0$. Frosts were quite general on the 29th and 30th.

BAROMETER.

The mean barometer, 30·07, is very nearly normal. The highest pressures noted were on the 6th and 7th, and were about ·10 above those generally occurring during September. The lowest pressure was on the 26th, but was not unusual.

PRECIPITATION.

The average monthly rainfall for the state, was 4·84 inches, which is about 1·35 inches more than the average. It was nearly normal west of the Susquehanna River. The largest monthly totals occurred at Bethlehem, 10·93 inches; Quakertown, 9·36 inches, and Girardville, 8·18 inches. The lowest, at Pittsburgh, 1·77 inches, and Wellsboro, 1·75 inches. A number of stations reported light snow on the 29th and 30th.

WIND AND WEATHER.

The weather was generally favorable for the ripening and harvesting of corn, buckwheat and late vegetables. But little damage was done by frosts. Some delay occurred in seeding when the moisture was excessive. Winter wheat is reported as looking well. No severe gales passed over the state.

Average number.—Rainy days, 10; clear days, 8; fair days, 11; cloudy days, 11.

MISCELLANEOUS PHENOMENA.

Thunder-Storms.—Reading, 12th; Kutztown, 12th, 20th; Hollidaysburg, 12th; Quakertown, 12th, 20th; Johnstown, 12th; West Chester, 16th; Coatesville, 12th, 16th; Lock Haven, 9th; Carlisle, 12th; Lancaster, 12th, 30th; Lebanon, 20th; Greenville, 8th; Pottstown, 12th; Shamokin, 12th; New Bloomfield, 12th; Philadelphia, 13th, 16th, 20th; Somerset, 12th, 28th; Eagles Mere, 12th, 30th; Bernice, 12th; Wellsboro, 9th, 20th; Columbus, 12th, 28th; Dyberry, 12th.

Hail.—Charlesville, 28th, 29th; Johnstown, 12th; Phillipsburg, 28th; Lock Haven, 29th; Tionesta, 29th; Lancaster, 29th; Smethport, 29th, 30th; Shamokin, 29th; Girardville, 29th; Selins Grove, 13th, 28th; Eagles Mere, 29th; Bernice, 30th; Wellsboro, 29th; York, 29th.

Snow.—Johnstown, 29th; Emporium, 30th; Phillipsburg, 29th; Clarion, 29th; Grampian Hills, 28th, 29th; Tionesta, 30th; Indiana, 30th; Cornwall, 29th; Smethport, 29th, 30th; Shamokin, 29th; Girardville, 29th; Somerset, 29th; Eagles Mere, 29th, 30th; Bernice, 29th; Wellsboro, 29th, 30th; Columbus, 30th; Dyberry, 30th; Honesdale, 30th.

Frosts.—Pittsburgh, 14th; Charlesville, 14th, 30th; Wysox, 6th, 7th, 29th, 30th; Quakertown, 29th, 30th; State College, 29th; Phillipsburg, 13th, 14th; West Chester, 29th; Coatesville, 30th; Clarion, 30th; Grampian Hills, 14th, 29th; Catawissa, 14th, 28th, 29th; Carlisle, 30th; Swarthmore, 30th; Uniontown, 14th, 30th; Tionesta, 6th, 14th; McConnellsburg, 30th; Indiana, 29th, 30th; Lancaster, 29th, 30th; New Castle, 14th, 30th; Greenville, 14th; Shamokin, 29th, 30th; New Bloomfield, 29th; Philadelphia, 30th; Girardville, 29th; Selins Grove, 29th, 30th; Somerset, 14th; Eagles Mere, 29th;

Bernice, 6th, 7th, 14th, 15th, 29th, 30th; Wellsboro, 6th, 7th, 28th, 29th, 30th; Columbus, 6th, 14th, 29th, 30th; Dyberry, 6th, 7th, 14th, 15th, 28th, 29th, 30th; Honesdale, 7th; York, 29th, 30th.

Coronce.—Lancaster, 6th; Bernice, 15th, 18th, 25th.

Solar Halos.—Charlesville, 9th, 30th; Eagles Mere, 3d, 6th, 9th, 10th, 15th.

Lunar Halos.—Pittsburgh, 16th; Quakertown, 15th; Indiana, 17th.

Auroras.—Wellsboro, 26th.

T. F. T.

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhart, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm. A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.
State Normal School, ...	Clarion.

<i>Displayman.</i>	<i>Station.</i>
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.

1

	Lansdale.	Forks of Nesham'y.
	30	.
	.	.
	.	.
	.	.
	176	311
	39	.
	29	126
	.	.
	.	.
	292	311
	54	70
	.	.
	.	.
	26	25
	08	.
	.	.
	649	84

14

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR SEPTEMBER, 1888.

COUNTY.	STATION.	Elevation above Sea Level (feet).	BAROMETER.			TEMPERATURE.										PRECIPITATION.			NUMBER OF DAYS.			WIND.						
			Mean.	Highest.	Lowest.	MAXIMUM.		MINIMUM.		DAILY RANGE.		Mean.	Greatest.	Date.	Least.	Date.	Relative Humidity.	Dew Point.	Total inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.				
						Mean.	Highest.	Date.	Lowest.	Date.	Mean.													Maximum.	Minimum.	A. M.	P. M.	P. M.
Allegheny	Pittsburgh,	847	30.066	30.380	29.960	60.2	81.2	9	39.2	30	60.6	54.6	16.0	30.1	14	6.2	1	75.7	52.0	1.77	9	4	9	17	NW	SW	NW	Clear D. Stewart, et
Beaver	Beaver,	821	30.066	30.380	29.960	58.3	81.2	4, 9	15.0	30	60.3	50.3	10.0	27.0	4, 7	8.0	20	88.5	54.5	1.20	6	12	4	14	W	W	W	W
Bedford	Charlestown,	1,300	30.066	30.380	29.960	50.5	81.2	12	14.5	14	60.0	48.1	18.8	13.5	14	4.0	7	85.5	50.3	1.37	9	6	14	10	NW	NW	SW	Rev. A. D. Thomas, et
Berks	Reading,	304	30.066	30.380	29.960	62.0	82.0	12	14.0	29	71.2	51.6	19.6	30.0	15	7.0	17	83.3	57.6	1.57	12	1	1	10	NW	NW	NW	C. M. Deane, C. E.
Berks	Kittanning—	540	30.066	30.380	29.960	59.5	83.1	19	35.5	29	68.8	53.3	15.5	27.0	19	5.0	9	77.7	52.0	1.35	11	1	1	1	W	W	W	Prof. J. H. R. Stewart
Butler	Altoona,	1,181	30.066	30.380	29.960	61.1	79.0	10, 13	40.0	30	70.3	59.9	10.4	27.0	15	11.0	17	70.9	41.5	1.30	8	1	1	1	W	W	W	Dr. Charles E. L. Moore
Butler	Harrisburg,	947	30.066	30.380	29.960	59.0	83.0	12	15.0	30	70.3	59.9	10.4	27.0	14	13.0	17	90.0	57.0	1.34	7	14	7	7	W	W	W	Prof. J. A. Stewart
Butler	Wysox,	718	30.066	30.380	29.960	60.7	78.4	9	13.0	30	68.2	49.6	18.6	29.0	7	10.5	1	82.8	52.3	1.49	8	5	9	16	NW	NW	SW	Charles Bercher
Butler	Chambersburg,	536	30.066	30.380	29.960	60.9	78.4	12	13.5	30	71.5	51.1	20.4	30.5	24	8.5	9, 17	81.8	56.1	1.36	14	6	11	13	NW	NW	SW	J. E. F. H. H. H.
Butler	Butler,	1,184	30.066	30.380	29.960	57.2	83.0	4, 9	37.0	29	70.1	50.7	19.5	33.0	14	10.0	28	81.1	49.0	1.70	1	11	14	5	SW	SW	SW	E. C. Lorenz
Cameron	Emporium,	1,030	30.066	30.380	29.960	59.7	83.0	4	35.0	30	70.1	46.8	23.5	33.0	4	12.0	16	77.7	47.2	1.57	10	10	10	10	W	NW	SW	T. B. Lloyd
Centre	State College,	1,101	30.068	30.380	29.975	57.7	77.0	9	32.0	30	65.2	46.1	18.9	31.0	14	9.0	17	83.3	51.5	1.12	4	6	10	14	W	W	W	Prof. W. F. Frazier
Centre	Agricultural Experiment Station,	1,350	30.068	30.380	29.975	57.7	77.0	11	14.0	30	67.3	47.2	20.1	31.0	14	6.0	15	78.0	44.5	1.37	12	4	10	7	SW	SW	SW	L. Ray M. R.
Chester	West Chester,	455	30.070	30.380	29.960	60.3	80.0	12	15.0	30	69.8	55.7	14.1	25.0	12	4.0	17	78.0	44.5	1.59	11	12	10	11	W	NW	NW	Prof. John A. R.
Chester	Coteseville,	380	30.070	30.380	29.960	64.6	84.0	12	34.0	30	69.8	55.7	14.1	25.0	15	7.5	17	83.3	57.6	1.59	15	10	9	11	W	W	W	W. T. Gordon
Clarion	Kimberburg,	1,500	30.070	30.380	29.960	57.7	77.0	9	32.0	30	65.2	46.1	18.9	31.0	14	9.0	17	83.3	51.5	1.12	4	6	10	14	W	W	W	Rev. W. W. D. Stewart
Clarion	Clarion,	1,500	30.070	30.380	29.960	57.7	77.0	11	14.0	30	67.3	47.2	20.1	31.0	14	6.0	15	83.3	51.5	1.37	12	4	10	7	SW	SW	SW	Thomas F. Sloan
Clearfield	State Normal School,	1,530	30.070	30.380	29.960	55.4	78.5	9	32.0	29	67.5	45.4	22.1	31.0	12, 14	9.0	16	83.7	39.2	2.82	7	6	13	6	S	S	S	C. M. Thomas, B. S.
Clearfield	Grampian Hills,	1,480	30.070	30.380	29.960	55.2	80.0	9	32.0	29	67.4	47.7	17.7	36.0	14	4.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Thomas Moore
Clinton	Lock Haven,	560	30.070	30.380	29.960	61.9	80.0	18, 19	34.0	29	68.1	49.6	18.7	29.0	15	5.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. Albert E. M.
Columbia	Meadville,	491	30.070	30.380	29.960	61.5	80.0	12	38.5	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	J. F. Ba-master
Crawford	Allegheny College,	1,050	30.070	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	A. M. Schell, L. A. B.
Cumberland	Harrisburg,	480	30.080	30.380	29.960	60.3	80.0	12	36.5	30	68.1	55.2	12.9	22.3	12	5.0	11	81.5	59.8	1.44	12	3	11	10	NW	NW	SW	Wm. T. Bazz
Delaware	Swarthmore,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	George W. Hayes, C. E. P.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	H. D. Miller, M. D.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Armstrong & B.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. S. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	N. C. Mifer, M. D.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Charles Moore, D. D. S.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Leitch & E. C.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	C. R. Hanley
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Frank M. H.
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	L. M. Boyer
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	W. M. Schrock
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	F. S. Chase
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	C. C. Clapp
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	A. H. Berlin
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	H. D. Deming
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960	61.7	81.5	12	42.0	30	70.2	49.8	20.4	26.0	14	8.0	17	83.7	39.2	2.82	7	6	13	6	S	S	S	Prof. N. H. M. er
Delaware	Swarthmore College,	190	30.080	30.380	29.960																							

[illegible]

PRECIPITATION FOR SEPTEMBER, 1888.

[illegible]

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR OCTOBER, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 31, 1888.

TEMPERATURE.

The mean temperature for the month of October was $46^{\circ}\cdot 1$, which is about 6° below the average, and largely increases the temperature deficiency since January 1st, which, at the close of the month at Philadelphia, amounts to $59\cdot 5^{\circ}$, or an average of nearly 2° per day for the past year.

The highest temperatures during the month were below those generally attained in October, while the lowest were about the same. The former occurred on the 1st, and most of the latter on the 10th, although several stations report other dates.

The highest recorded were, Columbus, 74° ; Pittsburgh, $73^{\circ}\cdot 8$; Beaver, 73° ; Charlesville, 73° , and New Castle, 73° . The lowest were, Clarion, $19^{\circ}\cdot 2$; Greenville, $20^{\circ}\cdot 5$; Coudersport, 21° ; Dyberry, 22° , and Honesdale, 23° . The means of the daily maxima and minima from fifty stations are, respectively, $54^{\circ}\cdot 7$ and $38^{\circ}\cdot 0$. These give a mean of $46\cdot 3$, which differs only two from the mean ($46\cdot 1$) derived from the tri-daily observations.

BAROMETER.

The range of pressure was very nearly the same that usually occurs in October, and the mean, $29\cdot 98$, is about $\cdot 10$ below the average.

The lowest pressure was during the warm period of the 1st, and the highest on the 26th and 31st.

PRECIPITATION.

The average rainfall over the state for the month was $4\cdot 02$, which is an excess. Very few heavy rainfalls occurred, but the days on which rain fell were so numerous that the month has been unusually wet and disagreeable.

The percentage of humidity ranged high, and there was more than the usual number of cloudy days. A few snowfalls were reported, but they were light. The greatest was one inch at Somerset.

WIND AND WEATHER.

The average direction of wind was from the northwest. There were no severe gales and the prominent features of the weather were cold and wet.

Average number.—Rainy days, 16; clear days, 6; fair days, 9; cloudy days, 16.

MISCELLANEOUS PHENOMENA.

Thunder-Storms.—Beaver, 1st; Reading, 6th; Kutztown, 17th; Hollidaysburg, 19th; Quakertown, 6th, 17th; State College, 1st; Phillipsburg, 1st, 16th, 19th; West Chester, 17th, 19th; Coatesville, 17th; Rimersburg, 16th, 19th; Grampian Hills, 1st; Lock Haven, 1st, 16th, 19th; Catawissa, 19th; Carlisle, 17th; Swarthmore, 17th; Uniontown, 1st, 19th; Tionesta, 19th; McConnellsburg, 19th; Indiana, 16th, 17th; Lancaster, 6th, 17th, 19th; New Castle, 1st, 16th, 18th; Lebanon, 17th; Greenville, 19th; Pottstown, 17th; Bethlehem, 6th; New Bloomfield, 16th, 19th; Philadelphia, 17th; Coudersport, 1st; Somerset, 1st, 19th; Eagles Mere, 1st, 16th; Wellsboro, 16th; Columbus, 16th; York, 6th, 13th, 19th.

Hail.—Phillipsburg, 16th; Lock Haven, 16th; Catawissa, 11th; Indiana, 20th; Eagles Mere, 8th, 16th, 22d; Bernice, 29th; Columbus, 16th; Dyberry, 8th, 20th.

Snow.—Phillipsburg, 3d, 20th; Rimersburg, 3d, 12th, 21st; Clarion, 20th; Grampian Hills, 20th, 21st; Lock Haven, 3d; Indiana, 20th; Scranton, 3d; Greenville, 3d, 20th, 21st; Shamokin, 3d; Coudersport, 3d; Somerset, 3d, 12th, 20th; Eagles Mere, 3d, 8th, 20th, 21st, 29th; Bernice, 9th, 29th; Wellsboro, 2d, 3d, 20th; Columbus, 3d, 20th; Dyberry, 3d, 9th, 21st, 28th.

Frosts.—Pittsburgh, 4th, 29th, 10th; Beaver, 10th; Charlesville, 3d, 4th, 31st; Reading, 11th, 15th, 18th, 25th, 31st; Kutztown, 10th; Hollidaysburg, 3d, 4th, 9th, 10th, 11th, 30th, 31st; Wysox, 9th, 10th, 11th, 14th, 15th, 18th, 19th, 20th, 21st, 22d, 24th; Quakertown, 4th, 9th, 10th, 11th, 13th, 15th, 21st, 22d, 25th, 30th, 31st; State College, 3d, 4th; Phillipsburg, 3d, 4th, 10th, 11th, 20th, 25th; West Chester, 4th; Coatesville, 3d, 4th, 10th, 11th, 15th, 22d, 25th, 30th; Rimersburg, 18th; Lock Haven, 3d, 10th, 11th, 15th, 25th, 26th, 29th, 30th, 31st; Catawissa, 3d, 5th, 10th, 11th, 15th, 18th, 20th, 22d, 25th, 31st; Carlisle, 4th, 5th, 10th, 15th, 25th, 31st; Harrisburg, 4th, 15th; Swarthmore, 4th, 10th, 22d, 31st; Erie, 10th; 11th, 15th; Uniontown, 4th, 30th, 31st; McConnellsburg, 3d, 4th, 31st; Huntingdon, 3d, 4th, 11th, 22d, 25th, 30th, 31st; Indiana, 3d, 4th, 10th; Scranton, 18th; Lancaster, 3d, 4th, 10th, 15th, 18th, 22d, 25th, 30th, 31st; New Castle, 4th, 10th, 15th, 25th; Lebanon, 3d, 4th, 25th, 31st; Greenville, 10th, 11th, 15th, 25th, 30th; Pottstown, 4th, 9th, 10th, 11th, 15th, 22d; Bethlehem, 10th, 11th, 25th; New Bloomfield, 4th, 5th, 15th, 29th; Philadelphia, 4th, 10th, 31st; Coudersport, 3d, 9th, 10th, 11th; Selins Grove, 3d, 5th, 10th, 21st, 25th, 30th, 31st; Somerset, 4th, 10th, 11th, 18th, 20th, 21st, 22d, 25th, 29th, 30th, 31st; Eagles Mere, 10th, 15th, 18th,

25th, 31st; Bernice, 9th, 10th, 11th, 15th, 18th, 20th, 25th, 26th; Wellsboro, 11th, 15th, 20th, 21st, 22d, 25th; Columbus, 3d, 9th, 10th, 11th, 15th, 19th, 21st, 22d, 25th, 30th, 31st; Dyberry, 1st, 3d, 4th, 9th, 10th, 11th, 15th, 16th, 18th, 19th, 20th, 21st, 22d, 25th, 26th, 30th, 31st; York, 4th, 10th, 11th, 13th, 15th, 18th, 22d, 25th.

Coronæ.—Reading, 19th; Rimersburg, 18th; Lancaster, 24th; Eagles Mere, 18th, 20th.

Solar Halos.—Wellsboro, 10th, 15th, 18th; Eagles Mere, 11th, 18th, 22d, 26th; Dyberry, 15th, 18th, 26th, 29th.

Lunar Halos.—Reading, 18th; Kutztown, 18th; Quakertown, 18th, 22d; West Chester, 18th; Clarion, 21st; Lock Haven, 18th; Carlisle, 18th, 24th; Indiana, 21st; Lancaster, 18th, 24th, 25th; Lebanon, 18th, 26th; Shamokin, 18th; Philadelphia, 18th; Eagles Mere, 18th; Wellsboro, 18th; Dyberry, 11th, 26th; York, 18th.

The policy of the Chief Signal Officer with regard to display stations is very liberal, and where the weather signals will prove of value to the public, dispatches will be sent to selected points that are properly equipped for display.

A few sets of weather, temperature, and cold wave signal flags will be furnished by the Pennsylvania State Weather Service to those who will attend to their display. Application for the establishment of the stations and for flags should be made at once.

In order that there may be no unnecessary delay in the issue of the Monthly Weather Review, observers are requested to send in their reports as early and as complete as practicable.

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhart, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.

<i>Displayman.</i>	<i>Station.</i>
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm. A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.

Con		
	Date.	Relative Humidity.
Allegheny	21	72.8
Beaver	6, 13	86.0
Bedford	26	75.6
Berks,	12	85.0
Berks,	1, 23	...
Blair, ²	19	68.2
Blair,	27	90.0
Bradford	21	82.5
Bucks,	12	83.2
Butler,	...	...
Cambria	...	...
Camero	14, 19	79.7
Centre,	27	81.0
Centre,	12	...
Chester	12	...
Chester	12	...
Clarion,	20	...
Clarion,	8	81.9
Clearfie	12, 13	...
Clinton,	28	...
Columb	28	...
Crawfo	...	...
Cumber	12	76.3
Dauphin	24	75.6
Delawa	12	75.4
Elk, .	...	...
Erie, ¹	6	75.6
Fayette	20	76.2
Forest,	13	85.1
Franklin	...	...
Gulton,	6	80.0
Hunting	20	...
Indiana	13	81.0
Jackaw	7	78.0
Lancast	23	75.1
Lawren	21	85.4
Lebano	12, 23	77.6
Luzerne	30	...
Lycomi	...	...
McKea	21	...
Mercer	16	83.9
Monroe	...	...
Montgo	24	80.0
Northai	12, 21	84.0
Northu	6	78.8
Perry,	12	...
Philade	24	71.8
Pike, .	...	...
Potter,	...	80.0
Schuylk	6	...
Snyder	12	76.7
Tomers	26	91.1
Sullivar	14	87.0
Sullivan	14	87.0
Tusquel	...	...
Unga,	...	82.2
Wenang	...	...
Washin	...	...
Washin	20	85.4
Warren	9, 21	...
Wayne	9, 21	...
Wayne	...	...
Vestnu	23, 26	75.9
York, ¹	...	...

[CE.

y of the

TUTE,
30, 1888.

ut normal.
xima was

ire for the
nd Phila-

o; Wells-

Meadville,
iana, 77°.
Vellsboro,
rg, 10° 0;
2 23d.

ber, with
17th, 18th
ressure of
attended

PRECIPITATION FOR OCTOBER, 1888.

[illegible]

T. F. T.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR NOVEMBER, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 30, 1888.

TEMPERATURE.

The mean temperature for November was $42^{\circ}\cdot 0$, which is about normal. The average daily range was $16^{\circ}\cdot 9$. The mean of the daily maxima was $50^{\circ}\cdot 6$, and that of the daily minima $33^{\circ}\cdot 7$.

The following stations reported the highest average temperature for the month: Shamokin, $47^{\circ}\cdot 9$; Catawissa, $46^{\circ}\cdot 3$; Pottstown, $46^{\circ}\cdot 0$, and Philadelphia, $45^{\circ}\cdot 8$.

The lowest averages were, Greenville, $35^{\circ}\cdot 3$; Eagles Mere, $37^{\circ}\cdot 0$; Wellsboro, $37^{\circ}\cdot 2$; Phillipsburg, $37^{\circ}\cdot 5$, and Dyberry, $37^{\circ}\cdot 6$.

The highest temperatures recorded during the month were, Meadville, 79° ; Phillipsburg, 77° ; Catawissa, 77° ; Carlisle, 77° , and Indiana, 77° . These occurred on the 1st. The lowest were, Eagles Mere, $4^{\circ}\cdot 0$; Wellsboro, $6^{\circ}\cdot 0$; Dyberry, $8^{\circ}\cdot 0$; Honesdale, $9^{\circ}\cdot 0$; Wysox, $10^{\circ}\cdot 0$; Phillipsburg, $10^{\circ}\cdot 0$; Smethport, $10^{\circ}\cdot 0$, and Coudersport, $10^{\circ}\cdot 0$. These were noted on the 23d.

BAROMETER.

The barometer averaged about $\cdot 08$ below the mean for November, with the usual extremes. Most of the high pressures occurred on the 17th, 18th and 23d. The coldest period of the month was during the high pressure of the 23d. The low pressures were during the 10th and 26th, and were attended

by heavy rains. The low of the 26th caused severe gales along the coast, where considerable damage was done to shipping and sea-side resorts.

PRECIPITATION.

An average rainfall of 3.37 inches was quite evenly distributed throughout the state. The greatest amount in any one day fell on the 15th, on which date several stations had over one inch. There were ten days during the month on which general rains did not occur. Several light snowfalls were reported. The largest total snowfalls for the month, in inches, were, Eagles Mere, 10.50; Wellsboro, 6.55; Rimersburg, 4.25; Grampian Hills, 4.00; Carlisle, 3.00; Uniontown, 3.25; Huntingdon, 3.35; Scranton, 3.00; New Bloomfield, 3.00; Girardville, 3.00, and Dyberry, 3.00. Very little remained on the ground at the end of the month.

WIND AND WEATHER.

The average direction of wind was from the west. A severe northerly gale took place on the 26th. The month as compared with other Novembers had no distinguishing characteristics.

Average number.—Rainy days, 11; clear days, 9; fair days, 7; cloudy days, 14.

MISCELLANEOUS PHENOMENA.

Thunder-Storms.—Quakertown, 10th; New Bloomfield, 10th; Wellsboro, 10th; Columbus, 10th; Dyberry, 10th.

Snow.—Charlesville, 11th, 18th, 19th, 27th, 29th; Reading, 23d, 24th, 25th; Hollidaysburg, 18th, 26th; Wysox, 25th; Emporium, 11th, 16th, 17th, 18th, 26th, 29th; State College, 10th, 11th, 19th, 26th, 28th, 29th; Phillipsburg, 11th, 16th, 17th, 18th, 26th, 28th, 29th, 30th; West Chester, 24th, 25th; Coatesville, 24th, 25th, 26th; Rimersburg, 11th, 16th, 17th, 26th, 28th, 29th, 30th; Grampian Hills, 18th, 26th, 28th, 30th; Lock Haven, 18th, 26th; Catawissa, 17th, 18th, 25th; Meadville, 28th, 29th; Carlisle, 18th, 25th; Uniontown, 16th, 26th; McConnellsburg, 19th; Huntingdon, 19th, 26th; Indiana, 26th, 29th; Scranton, 25th; Lancaster, 23d, 25th, 26th; New Castle, 16th, 26th, 27th; Greenville, 16th, 17th, 18th, 26th, 27th, 28th, 29th, 30th; Bethlehem, 23d, 25th; New Bloomfield, 18th; Philadelphia, 24th, 25th, 26th; Coudersport, 26th, 30th; Eagles Mere, 11th, 16th, 17th, 18th, 25th, 29th, 30th; Wellsboro, 11th, 16th, 19th, 26th; Columbus, 16th, 27th, 28th, 29th, 30th; Dyberry, 19th, 25th; York, 25th.

Coronæ.—Catawissa, 14th; Huntingdon, 17th; Lebanon, 17th, 20th, 21st; Eagles Mere, 12th, 15th, 17th; Dyberry, 14th; York, 17th.

Solar Halos.—Charlesville, 2d, 4th, 14th; Altoona, 8th; Lebanon, 14th; Greenville, 4th, 14th; Philadelphia, 14th; Eagles Mere, 14th; Wellsboro, 14th; Dyberry, 14th.

Lunar Halos.—Charlesville, 17th; Reading, 14th, 19th; Hollidaysburg, 14th, 17th; Quakertown, 14th; West Chester, 17th; Rimersburg, 14th; Grampian Hills, 13th, 17th; Carlisle, 17th, 22d; Indiana, 14th; Lancaster, 15th; New Castle, 17th; Lebanon, 14th, 17th; Greenville, 14th, 17th; Phila-

delphia, 14th; Eagles Mere, 14th, 17th; Wellsboro, 14th; Dyberry, 14th; York, 14th.

Polar Banas.—Coudersport, 8th.

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhart, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm. A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.

<i>Displayman.</i>	<i>Station.</i>
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.
M. Tannehill, ...	Confluence.
S. C. Burkholder, ...	Pollock.
Robt. M. Graham, ...	Catawissa.
Henry F. Bitner, ...	Millersville.
A. J. Edelman, ...	Pottstown.
A. M. Wildman, ...	Langhorn.
N. E. Graham, ...	East Brady.
B. F. Gilmore, ...	Chambersburg.
Frank M. Morrow, ...	Altoona.
A. Simon's Sons, ...	Lock Haven.
E. W. McArthurs, ...	Meadville.
J. K. M. McGovern, ...	Lock No. 4.
A. M. Row, ...	Clearfield.

LATE WEATHER S

COUNT	PREC			Point Pleasant.	Rimersburg.
	Dew Point.	Total Inches.	Total Snowfall During Month		
gheny, ⁴ 6	35'8	3'57	..		
ver, ..	..	..	2'00		
ford, ..7	32'9	3'01	2'00		
ks, ..5	40'9	4'06	1'25		
ks, ..	..	..	..		
er, ² ..6	36'2	2'45	..		
r, ..0	39'0	3'05	2'00		
iford, ..6	34'5	3'27	3'00		
ks, ..4	37'7	3'71	..		
er, ..	..	..	..		
abria, ..	..	..	..		
eron, ..0	33'0	2'56	'50		
tre, ..	..	..	..		
re, ..0	36'5	2'71	1'08		
re, ..	..	3'57	2'00		
ster, ..0	35'5	3'94	1'00		
ster, ..	..	3'36	1'00		
ion, ..	..	..	4'25		
ion, ..	..	..	..		
rfield, ..	..	3'66	4'00		
ton, ..	..	4'59	2'50		
mbia, ..0	36'8	3'79	1'00		
yford, ..	..	..	..		
berland ²	..	3'22	'30		
phin, ¹ ..7	35'5	2'88	3'00		
ware, ..	35'5	2'30	'50		
l, ..2	38'6	4'13	'25		
tte, ..0	39'0	3'38	..		
st, ..	..	3'36	3'25		
klin, ¹ ..	..	..	..		
on, ..2	35'4	..	..		
on, ..0	38'0	3'14	1'00		
tingdor	..	..	..		
ina, ..	..	2'95	3'35		
awann ¹	39'2	2'75	2'50		
aster, ..	37'4	4'36	3'00		
rence, ..7	38'4	2'97	1'00		
non, ..1	40'5	3'99	'11		
rne, ..2	38'6	3'46	1'00		
ean, ..	..	..	..		
er, ..	..	4'01	..	3'55	4'25
gomer, ⁸	30'2	5'17	2'00		
hampte ⁵	57'8	3'42	'50		
humbel ⁰	38'0	3'82	2'00		
y, ..	..	1'99	..		
delphu ⁴	..	2'89	3'00		
er, ..4	38'3	3'77	'50		
ylkill, ..	34'2	2'10	2'00		
ler, ..5	..	4'90	3'00		
erset, ..1	37'4	2'43	2'25		
van, ..0	36'3	2'74	2'00		
uehann ⁰	33'5	6'22	10'50		
a, ..6	40'0	3'68	6'55		
ingo, ..	..	..	..		
ren, ..	..	3'81	..		
ne, ..	..	4'61	3'00		
ne, ..	..	3'97	2'00		
morela ¹	..	..	..		
l, ..4	36'9	2'68	2'50		

Point Pleasant.

Rimersburg.

3'55 4'25

T. T.

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR NOVEMBER, 1888.

[illegible]

Observations taken at 8 A. M. and 8 P. M. † Observations taken at 12 Noon.

T. F. TOWNSEND, Sergeant, Signal Corps, 4th Regt.

Eric	Reading.	Scranton.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Honesdale.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Condersport.	Seisholtzville.	Frederick.	Ottsville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Rimersburg.
'05 '30 '34 '51 '28 '46 '10	'06 '21 	 '07 	 	'03 '04 '05 	 	 	'36 '25 	'03 	'11 	'02 	'01 	'10 	'05 	'08 	'35 	'11 	 	 	'03 	 	 	
'34 '03 '24 '35 '74 '68 '40	 	'07 	 	'01 	'20 	'03 	'30 	'59 '85 '35 	'12 '39 '14 '12 '20 	'02 '39 '14 '12 '20 	'01 	'30 	 	'28 	'48 	'28 '50 	'74 	'10 	'03 	 	 	
'21 '06 	'27 '06 	'97 '05 	'25 '06 	'05 '07 	'11 	'17 '02 	'59 '64 	'23 '08 '02 	'56 	'41 '05 	'40 '20 	'51 	'03 '05 	'11 '18 	'34 '07 	'14 	'85 '15 	'49 '13 	'03 	'08 	 	
'13 '17 	'02 	'55 	'00 	'12 '02 	'08 	'76 	'68 	'16 	'07 	'97 	'67 	'30 	'16 	82 	'79 	'85 	'75 	'91 	'65 	'77 	 	
'15 '17 '05 '30 '16	'05 '62 '49 '21 '05 '01	'35 	'35 	'01 '05 '37 '05 	'02 '32 	'15 '16 	'31 '07 '09 	'40 	'10 	'40 	'01 '13 '03 	'10 	'12 	'56 	'72 	'70 	'48 	'22 	'61 '52 	'06 	'09 	
3'38	4'06	4'36	3'42	3'94	3'36	4'61	3'97	3'82	3'71	4'13	3'77	2'10	4'14	2'80	3'47	3'90	3'74	3'41	3'31	3'87	3'55	4'25

T. F. T.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR DECEMBER, 1888.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, December 31, 1888.

TEMPERATURE.

The mean temperature for December, determined from the tri-daily observations, was $32^{\circ}6$ which is slightly above the normal.

The mean daily maximum and minimum, 40° and 25° respectively, give a monthly mean of $32^{\circ}5$. The highest temperatures reported were Pittsburgh, $62^{\circ}1$; Tionesta, $62^{\circ}0$; Meadville, $61^{\circ}0$ and Philadelphia, $61^{\circ}0$. The lowest were Columbus, minus 10° ; Clarion, minus 9° and Greenville, minus 4 .

The warmest period of the month was on the 26th and the coldest on the 22d.

BAROMETER.

The mean pressure for the state, $30\cdot10$, was about normal. The highest occurred on the 30th and the lowest on the 17th. The latter was accompanied by heavy rains throughout the state.

PRECIPITATION.

The average rainfall, 3'14, is slightly above the normal. Some deficiencies occurred in the western part of the state. Most of the eastern counties received an excess. More than half of the monthly total for the middle and eastern parts of the state fell on the 17th, causing freshets.

Flurries of snow were frequent. Many stations report only a "trace." The greatest totals for the month are, Meadville, 21 inches; Eagles Mere, 20 inches; Wellsboro, 13 inches; Tionesta, 13 inches; Girardville, 11 inches; Somerset, 7 inches; Uniontown, 7 inches and Columbus 6 inches. All of the snows melted rapidly and none remained on the ground at the end of the month.

WIND AND WEATHER.

No severe gales passed over the state during the month. The weather has been favorable for winter grain, which is reported in good condition.

Average number.—Rainy days, 9; clear days, 8; fair days, 8; cloudy days, 15.

Prevailing wind direction, northwest.

MISCELLANEOUS PHENOMENA.

Snow.—Charlesville, 3d, 4th, 6th, 13th, 21st; Reading, 1st, 4th, 13th, 21st; Hollidaysburg, 3d, 4th, 5th, 21st, 31st; Wysox, 4th, 5th; Emporium, 4th, 9th, 14th, 16th, 21st, 27th, 28th, 31st; State College, 4th, 9th, 18th, 19th; West Chester, 4th, 5th, 6th, 13th, 19th, 21st; Coatesville, 4th, 19th; Grampian Hills, 4th, 8th, 13th, 19th; Lock Haven, 4th, 9th, 18th, 28th; Carlisle, 4th; Tionesta, 1st, 4th, 9th, 14th, 17th, 19th, 28th; Indiana, 3d, 4th, 12th, 14th, 16th, 17th, 18th, 27th; Scranton, 9th, 28th; Lancaster, 1st, 4th, 13th; New Castle, 4th, 14th, 19th; Drifton, 4th, 9th, 17th, 19th; Smethport, 1st, 4th, 5th, 8th, 20th; Greenville, 1st, 3d, 4th, 5th, 6th, 8th, 9th, 12th, 13th, 14th, 17th, 18th, 19th, 20th, 21st, 22d, 25th, 26th, 28th, 31st; New Bloomfield, 4th; Philadelphia, 1st, 4th, 6th, 13th, 19th; Girardville, 7th, 9th, 17th, 18th; Selins Grove, 1st, 4th, 13th, 19th, 21st; Somerset, 1st, 4th, 6th, 14th, 18th, 19th, 21st; Eagles Mere, 1st, 4th, 5th, 6th, 8th, 13th, 16th, 18th, 21st, 27th; Wellsboro, 1st, 4th, 5th, 8th, 9th, 13th, 18th, 21st; Columbus, 1st, 4th, 5th, 6th, 8th, 13th, 18th, 19th, 20th, 27th; Dyberry, 1st, 3d, 4th, 5th, 6th, 8th, 9th, 12th, 13th, 18th, 19th, 20th, 21st, 22d, 28th; Westtown, 4th, 19th.

Coronæ.—Charlesville, 7th; Indiana, 7th; Lebanon, 7th, 12th, 14th, 15th, 20th, 21st, 25th; Somerset, 20th, 21st, 25th; Dyberry, 15th, 29th.

Solar Halos.—Charlesville, 22d, 26th; Somerset, 12th, 15th; Eagles Mere, 7th, 30th; Wellsboro, 6th, 30th; Dyberry, 7th.

Lunar Halos.—Charlesville, 7th, 12th, 15th, 19th, 26th; Wysox, 26th; Quakertown, 12th, 15th; West Chester, 15th; Coatesville, 15th; Harrisburg 7th, 12th, 15th, 27th; Lancaster, 12th, 15th; Lebanon, 11th, 12th, 15th; Eagles Mere, 15th; Dyberry, 29th; York, 12th.

Auroras.—Eagles Mere, 23d.

Parhelium.—Eagles Mere, 15th ; Dyberry, 4th.

WEATHER SIGNALS.

<i>Displayman.</i>	<i>Station.</i>
U. S. Signal Office, ...	Philadelphia.
Wanamaker & Brown, ...	"
Pennsylvania Railroad Company, ...	"
Continental Brewing Company, ...	"
Samuel Simpson, ...	"
B. T. Babbitt, ...	"
Western Meat Company, ...	"
Neptune Laundry, ...	"
Chester Oil Company, ...	Chester.
C. W. Burkhart, ...	Shoemakerville.
A. N. Lindenmuth, ...	Allentown.
C. B. Whitehead, ...	Bradford.
Capt. Geo. R. Guss, ...	West Chester.
Werner & Son, ...	Emporium.
C. E. Lenhart, ...	Latrobe.
Thomas F. Sloan, ...	McConnellsburg.
J. H. Fulmer, ...	Muncy.
W. T. Butz, ...	New Castle.
S. W. Morrison, ...	Oxford.
Capt. A. Goldsmith, ...	Quakertown.
J. L. Morrison, ...	Sharon.
Wm. A. Engel, ...	Shenandoah.
Wm. Schrock, ...	Somerset.
Postmaster, ...	Meadville.
Frank Ross, ...	Oil City.
Lerch & Rice, ...	Bethlehem.
John W. Aitken, ...	Carbondale.
Signal Office, ...	Erie.
J. R. Raynsford, ...	Montrose.
E. P. Wilbur & Co., ...	South Bethlehem.
Agricultural Experiment Station, ...	State College.
Signal Office, ...	Pittsburgh.
E. H. Baker, ...	Williamsport.
<i>New Era</i> , ...	Lancaster.
State Normal School, ...	Clarion.
Clarion Collegiate Institute, ...	Rimersburg.
E. S. Chase, ...	Eagles Mere.
Thiel College, ...	Greenville.
D. G. Hurley, ...	Altoona.
Armstrong & Brownell, ...	Smethport.
J. E. Forsythe, ...	Butler.

<i>Displayman.</i>	<i>Station.</i>
James H. Fones, ...	Tionesta.
Wister, Hacker & Savage, ...	Germantown.
W. J. Thompson & Co., ...	Clifton Heights.
Steward M. Dreher, ...	Stroudsburg.
State Normal School, ...	Millersville.
E. C. Wagner, ...	Girardville.
Hartford P. Brown, ...	Rochester.
L. H. Grenewald, ...	York.
J. E. Pague, ...	Carlisle.
C. L. Peck, ...	Coudersport.
H. D. Miller, ...	Drifton.
Smith Curtis, ...	Beaver.
M. Tannehill, ...	Confluence.
S. C. Burkholder, ...	Pollock.
Robt. M. Graham, ...	Catawissa.
Henry F. Bitner, ...	Millersville.
A. J. Edelman, ...	Pottstown.
A. M. Wildman, ...	Langhorn.
N. E. Graham, ...	East Brady.
B. F. Gilmore, ...	Chambersburg.
Frank M. Morrow, ...	Altoona.
A. Simon's Sons, ...	Lock Haven.
E. W. McArthurs, ...	Meadville.
J. K. M. McGovern, ...	Lock No. 4.
<i>Raftsmen's Journal</i> , ...	Clearfield.

	Relative Humidity.	Dew Point.
71°1	25°5	
73°0	22°9	
72°1	27°5	
74°0	25°0	
74°7	26°7	
82°6	27°0	
80°0	25°2	
89°5	28°8	
68°0	24°2	
83°6	24°5	
76°5	27°8	
71°2	26°0	
73°2	25°4	
77°7	27°3	
71°1	26°5	
71°0	27°0	
70°0	27°0	
68°8	26°0	
76°9	27°9	
87°1	23°0	
80°7	21°2	
81°1	23°4	
74°6	26°7	

Germantown.	Point Pleasant.
16	12
14	46
18	
276	300
51	58
06	04
381	420

C. T.

MONTHLY SUMMARY OF REPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR DECEMBER, 1888.

COUNTY.	STATION.	Elevation above Sea Level (feet).	BAROMETER.			TEMPERATURE.										Relative Humidity.	PRECIPITATION.				NUMBER OF DAYS.			WIND.			OBSERVERS.		
			Mean.	Highest.	Lowest.	MAXIMUM.			MINIMUM.			DAILY RANGE.					Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	PREVAILING DIRECTION.					
						Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.									Least.	Date.	7 A. M.		9 P. M.	9 P. M.
Allegheny,	Pittsburgh,	847	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Oscar D. Stewart, Sgt. Sig. Corps.	
Beaver,	Beaver,	821	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Smith Curtis.	
Berk,	Chesapeakeville,	1,300	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Rev. A. Thos. G. Apple.	
Berk,	Reading,	304	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	C. M. Dechant, C.E.	
Berk,	Kittanning,	540	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Prof. J. H. Rohrbach.	
Berk,	Keystone State Normal School,	540	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Dr. Charles B. Dudley.	
Berk,	Altoona,	1,041	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Prof. J. A. Stewart.	
Berk,	Holidaysburg,	947	30.093	30.540	29.410	35.0	60.1	26	12.2	22	42.0	29.6	12.4	28.1	15	3.3	9	71.1	25.0	1.66	14	4	5	22	NW	NW	NW	Charles Beecher.	
Berk,	Wysox,	718	30.080	30.610	29.740	35.5	56.0	25	6.7	22	43.3	23.1	20.2	35.0	24	7.0	10	82.6	27.0	4.75	6	12	8	11	NW	NW	NW	J. L. Hancock.	
Berk,	Quakertown,	536	30.080	30.610	29.740	35.5	56.0	25	6.7	22	43.3	23.1	20.2	35.0	24	7.0	10	82.6	27.0	4.75	6	12	8	11	NW	NW	NW	J. E. Forsythe.	
Berk,	Builer,	1,184	30.080	30.610	29.740	35.5	56.0	25	6.7	22	43.3	23.1	20.2	35.0	24	7.0	10	82.6	27.0	4.75	6	12	8	11	NW	NW	NW	C. E. Lorant.	
Berk,	Johnstown,	1,030	30.080	30.610	29.740	35.5	56.0	25	6.7	22	43.3	23.1	20.2	35.0	24	7.0	10	82.6	27.0	4.75	6	12	8	11	NW	NW	NW	T. B. Lloyd.	
Berk,	Emporium,	1,030	30.080	30.610	29.740	35.5	56.0	25	6.7	22	43.3	23.1	20.2	35.0	24	7.0	10	82.6	27.0	4.75	6	12	8	11	NW	NW	NW	Prof. Wm. Fear.	
Berk,	State College,	1,191	30.111	30.546	29.548	32.2	48.5	25, 26	1.0	22	37.7	20.6	17.1	35.0	24	6.0	11	89.5	28.8	2.94	1.37	10	6	4	21	W	W	W	Prof. Wm. Dunkle.
Berk,	Phillipsburg,	1,350	30.070	30.534	28.972	28.8	55.0	25	0.0	22	38.0	21.5	16.5	44.0	7	5.0	10	68.0	24.2	4.97	2.28	14	8	7	16	SW	SW	SW	Jesse C. Green, D.D.S.
Berk,	West Chester,	455	30.070	30.534	28.972	28.8	55.0	25	0.0	22	38.0	21.5	16.5	44.0	7	5.0	10	68.0	24.2	4.97	2.28	14	8	7	16	SW	SW	SW	W. T. Gordon.
Berk,	Coatesville,	380	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Westtown,	380	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Rimersburg,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	State Normal School,	1,530	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Nathan Moore.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Prof. John A. Robb.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Robert M. Graham.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	Rev. W. W. Deatrick, A.M.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25	6.0	11	80.0	25.2	2.94	6.75	7	14	9	8	NW	NW	NW	C. M. Thams, B.S.
Berk,	Claron,	1,500	30.155	30.580	29.120	33.0	60.0	27	15.0	22	43.1	27.2	15.9	28.0	25														

¹ Observations taken at 8 A. M. and 8 P. M. ² Observations taken at 12 Noon.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

	Erie.	Greenville.	New Castle.	West Chester.	Coatesville.	Dyberry.	Honesdale.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Coudersport.	Seisholtzville.	Frederick.	Otusville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.
1	'03	.	.	.	.	.	06	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	'01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	'03	'15	'02	'01	.	'04	'02	.	.	.	.	.	.	.	.	.	.	.	.	.
4	'06	'03	.	.	.	.	.	'04	.	.	.	.	.	.	.	.	.	.	.	.	.
5	'14	'20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	'03	'01	.	'14	'10	.	'12	.	'17	.	'03	'10	'11	'15	'17	'18	.	.	'15	'16	'12
7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	'36	'27	'45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9	'23	'19	.	'17	'12	'78	'51	'41	'42	'15	'15	'90	'38	'28	'53	'29	'36	'36	'17	'14	'46
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	'02	.	.	.	.	.	'15	'10	.	.	.	.	.	.	.	'10	'18	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	'02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	'08	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	'27	'24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17	'11	'04	'49	'76	'389	'182	'223	'261	'338	'296	'223	'70	'322	'334	'330	'289	'270	'275	'272	'276	'300
18	'23	'08	.	'06	'24	'30	.	.	'10	.	'05	'20	'10	'334	'330	'289	'270	'275	'272	'276	'300
19	.	'03	.	'02	'01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	'01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21	'05	'04	'03	.	.	.	'01	.	.	.	.	'10	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25	'02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	'01	'23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	'06	'10	.	'65	'75	'50	'62	'52	'64	'36	'54	'140	'67	'55	'66	'60	'55	'60	'55	'51	'58
28	'10	'02	.	.	.	.	'01	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	'08	'20	.	'13	'13	.	'01	'01	'04	'03	'05	.	.	'04	'07	'04	'04	'05	'05	'06	'04
	1'77	1'61	2'45	1'97	5'25	3'40	3'63	3'59	4'75	3'65	3'15	3'50	4'38	4'36	4'43	4'00	3'65	3'76	3'74	3'81	4'20

T. F. T.

PRECIPITATION FOR DECEMBER, 1888.

[illegible]

T. F. T.

List of Members of the Franklin Institute.

OCTOBER 1st, 1888.

- Abbott, Helen C. Des. Chemist, 1509 Locust st
 Adams, Harry C., 316 S. 15th st
 Adamson, J. Arthur, Mfr, Germantown rd and Columbia av
 Addicks, J. E., 425 Chestnut st
 Adler, Jno. M., M.D., 1028 Arch st
 Aichele, Christian, 2624 N. 5th st
 Albertson, Isaac, M.E., 234 Walnut st
 Albertson, Wm. Surveyor, 1200 Girard st
 Albrecht, Antonius C., Supt, cor Lehigh av and American st
 Albrecht, H., M.E., cor Lehigh av and American st
 Albrecht, Otto, Druggist, 655 N. 22d st
 Aldrich, Jos. W., Teacher
 Alexander, Chas. H., Mfr, 412 N. 3d st
 Alexander, Robert, Teacher, 22 N. 7th st
 Alsop, Samuel, Teacher, Trenton, N. J.
 Altemus, Henry, Publisher, 513 Cherry st
 Allen, A. W., Atty-at-law, 2011 Park av
 Allen, A. W., Chemist, Pencoyd, Pa.
 Allen, Daniel, Dyer, 2644 Frankford rd
 Allen, Jas. T., Plasterer, 116 S. 40th st
 Allen, John C., Druggist, 335 S. 5th st
 Allen, Jos., Jr., Furniture, 447 N. 12th st
 Allen, N. Penrose, Fertilizer, 124 S. Delaware av
 Allen, Samuel, Teacher, 316 S. 16th st
 Allen, Wm. E., Clerk, 1521 Pine st
 Allison, Wm. C., Car Builder, 32d and Walnut sts
 Anderson, Chas. A., Blacksmith, 3221 Woodlands av
 Anderson, Edw. L., M.D., 63d and Vine sts
 Anderson, Geo. W., Plumber, 1229 Girard av
 Andrews, A. Y., Electric Mach, 507 Arch st
 Angerer, Victor, Driftsman, 2831 Girard av
 Anshutz, John P., Driftsman, 2033 Arch st
 Areher, B. F., Iron Fdr, 319 Cooper st, Camden, N. J.
 Archer, Lefroy G., Printer, Lock box 52, Vineland, N. J.
 Arnold, Jas. McK., Printer, 420 Library st
 Armstrong, W. R., Clerk, care Powers & Weightman, 9th and Parrish sts
 Armstrong, Wm. A., M.D. 644 N. 12th st
 Ash, Samuel S., Mach, 1717 Vine st
 Ash, Thomas S., Clerk, 2052 Rush st
 Ashbridge, Richard, West Whiteland, Pa.
 Atlee, Walter, Engineer, 210 S. 13th st
 Atmore, Marshal, Watch Mkr
 Auchincloss, W. S., Bryn Mawr, Pa.
 Austin, W. L., M.E., 1621 Brown st
 Babbitt, Isaac, 971 Hutchinson st
 Bachman, Ernest, Mach, 1365 Heath st
 Bacon, Murray, Mach, 202 W. Cheltenham av
 Badia, Jos., 327 Pine st
 Baeder, Chas. B., Mfr. Gluc, 730 Market st
 Baily, Joel J., Mfr, 719 Market st
 Bainbridge, David, Shoe Dlr, 912 N. 6th st
 Baird, Alexander, Kimberton, Pa.
 Baird, H. C., Publisher, 810 Walnut st
 Baird, John, 1705 N. Broad st
 Baker, A. G., 421 Walnut st
 Baker, Chas. S., 522 Market st
 Baker, Geo. Fales, 1818 Spruce st
 Baker, Isaac F., Mfr, 1019 Arch st
 Baker, John G., Mach, 1922 N. 7th st
 Baker, Richard D., Chemist, 216 S. 3d st
 Baker, W. F., Chemist, 1542 N. 19th st
 Balderston, Mark, Builder, 508 Marshall st
 Ball, G. H., Engineer, 1816 Chestnut st
 Ball, Thos. H., Mfr, 25th and Callowhill sts
 Balliet, W. H., Tel Ins, 1104 Sp. Garden st
 Bancroft, J. Sellers, Mach, 1600 Hamilton st
 Bancroft, Milton H., Teacher, Swarthmore, Pa.
 Baneroft, Samuel, Jr., Wilmington, Del.
 Banes, Chas. H., Mfr, 2021 Sp. Garden st
 Banes, Warner J., Mfr, 2021 Sp. Garden st
 Barber, Henry Lee, Pharmacist, 2558 N. 7th st
 Barless, J. Chas., 12th and Thompson sts
 Barnard, I. S.
 Barnes, Lucy Sellers, Phila.
 Barnes, Thos., 4044 Powelton av
 Barnett, Chas. P., Steam Ftr, 218 N. 5th st
 Barnett, George, File Mfr, 21 Richmond st
 Bartol, George E., 262 S. 21st st
 Bartol, Henry W., Sugar Ref, 109 S. Front st
 Bartram, Jno. W., Mach, 428 West Norris st
 Bary, H. M. B., Iron Mkr, Wistar st., Gtn.
 Bate, W. T., Boiler Mkr, Conshohocken, Pa.
 Bates, Stockton, Treas. N. W. cor. 2d and Chestnut sts
 Bauer, Frederick, Confectioner, 1613 Fairmount av
 Baxter, Harry F., M.D., 242 Catharine st
 Baxter, Samuel, Jr., Pattern Mkr, Venango st. and Trenton av

- Baxter, Thos. E., 3504 Hamilton st
 Baylor, J. Roy, Jr., Elec Eng, Crozet. Albermarle Co., Va.
 Bean, Edw. L., Hotel Mgr
 Beardsley, Arthur, C. & M. Eng, Swarthmore, Pa.
 Beamont, Wm. V., Mach, 1536 Herbine st
 Beaver, Thos., Mer, Danville, Pa.
 Bechtel, Edw., Carpenter, 1819 Green st
 Becker, Geo. H., Conveyancer, 250 N. 5th st
 Beckhaus, Jos., Car Mfr, 1108 Shackamaxson st
 Beinitz, Max, M.E., 1329 Fairmount av
 Belfield, Alfred L., Brass Fdr, 435 N. Broad st
 Belfield, Henry, Brass Fdr, Broad and Noble sts
 Belfield, T. Broom. Brass Fdr, 435 N. Broad st
 Bell, Angelo R., 213 S. 5th st
 Bell, J. Snowden, Mech, P. O. Box 1034, Pittsburgh
 Bell, William, 2330 Montgomery av
 Bement, Clarence F., Mach, 2029 Callowhill st
 Bement, F., 2029 Callowhill st
 Bement, Wm. B., Mach, 2029 Callowhill st
 Bement, Wm. P., Mach, 2029 Callowhill st
 Bentley, Milan, 309 N. 3d st
 Bennett, H. R., Salesman, 1614 Green st
 Bennor, Jos., 2231 N. College av
 Berner, C. N., Brewer, 9 S. 7th st
 Beringer, G. M., Druggist, 932 S. 3d st, Camden, N. J.
 Betton, Thos. F., M.D., 4613 Germantown av
 Betts, R. L., Measurer, P. O. Box 70, Phila.
 Beverlin, Jas. H., Bkpr, 420 S. Del. av
 Bibighaus, S. H., Mer, 2307 Green st
 Hickerton, Thos., Upholsterer, 415 S. 9th st
 Biddle, Alex., Lawyer, 712 Walnut st
 Biddle Clement, Lawyer
 Biddle, Caldwell K., 1420 Walnut st
 Biddle, C. M., Hardware, 506 Commerce st
 Biddle, Elsie, 1420 Walnut st
 Biddle, E. R.
 Biddle, H. W.
 Biddle, Jas. C., Jr., 1420 Walnut st
 Biddle, Richard, 1011 Pine st
 Biddle, Samuel, Jeweler, 1429 Arch st
 Biddle, Sarah, 1420 Walnut st
 Biddle, Wm. T., President, 220 S. 4th
 Biddle, W. F., 209 S. 3d
 Biermann, Wm. J., Engv, 802 Marshall st
 Bilberg, C. O. C., Electrician, 103 S. 34th st
 Bilgram, Hugo, Mach, 1817 Olive st
 Bille, Alex., Engine Turn, 323 S. 5th st
 Binder, Geo. A., 928 Marshall st
 Binder, Jacob, Builder, 808 N. 7th st
 Birge, I., Mfr, 924 Arch st
 Birkinbine, John, Eng, 25 N. Juniper st
 Bisler, G. A., Paper Box Mfr, 328 Juliana st
 Blackwood, J. D., 22d and Washington av
 Blair, A. Andrew, Chemist, 919 Chant st
 Blakiston, Presley, Publisher, 1012 Walnut st
 Blanchard, Wm., 1511 Walnut st
 Blankenburg, Rudolph, 1326 Arch st
 Blasius, Wm., Musical Ins, 916 Arch st
 Blaul, Louis, Photographer, 1937 Gtn av
 Boekel, J., Mfr, 110 S. 8th st
 Boekel, Wm., Metal Spinner, 110 S. 8th st
 Boggs, Theo. C., Draughtsman, 700 Walnut st
 Bohn, Chas., Pharmacist, 901 N. 2d st
 Boissannas, A., Elec Eng, N. E. cor. 33d and Walnut st
 Boker, Chas. S., M.D., 1622 Chestnut st
 Boker, Geo. H., 1726 Walnut st
 Bond, A. G., Plumber, 1344 Ridge av
 Bonney, C. S., Mach, 3015 Chestnut st
 Bonta, Jas. W., Tel Eng, 1600 Diamond st
 Bonsall, C. P., Dentist, 515 Spruce st
 Bonwill, W. G. A., Dentist, 1721 Locust st
 Borda, Eugene, Coal, 326 Walnut st
 Borgner, Cyrus, Mfr, 231 N. 23d st
 Bortel, E. S., Roofer, 2217 Chestnut st
 Boswell, W. L., Insurance, 341 Walnut st
 Bottomley, Henry, Woollen Mfr, Camden, N. J.
 Bouchet, Edw. A., Teacher, 830 Lombard st
 Bournonville, Antoine, Mfr, 200 N. 3d st
 Bower, Wm. Henry, Chem, 27th and Gray's Ferry rd
 Bower, Geo. R., Secy, 27th and Gray's Ferry rd
 Bower, Henry, 27th and Gray's Ferry rd
 Boyce, Robert M., S. W. 13th & Walnut sts
 Boyd, J. T., M.E., 423 S. 15th st
 Boye, Dr. Martin H., Coopersburg, Lehigh Co., Pa.
 Boyer, Z. P., Inventor, 1829 N. Broad st
 Boyer, L. P., Jr., M.D., 1829 N. Broad st
 Bradley, Geo. W., Pattern Mkr, 310 N. Front st, Camden. N. J.
 Brady, Edw., 3815 Hamilton st
 Brandeis, Semi, Architect, 214 N. 5th st
 Brandon, Jos. W., Bank Clk, 1111 Walnut st
 Brannan, Jas., Gas Fixtures, 1218 S. 8th st
 Branson, D., Mer, 1118 Washington av
 Branson, Mary, M.D., 1719 Arch st
 Braselmann, J., Dyer, 210 S. 8th st
 Brearley, John H., 1840 Camac st
 Breban, J. C., Electrician, 1930 Sansom st
 Brehman, Chas. S., Chem App, 1721 Franklin st
 Brewer, H. M., Dentist, 210 W. Girard av
 Bridges, Robert, M.D.
 Brightley, Jos. H., Engraver, S. E. cor Ridge av and Spring Garden st
 Brill, G. M., Car Bldr, 31st and Chestnut sts
 Brinley, Chas. A., Chemist, 247 S. 16th st
 Brinton, Henry, 1915 Gratz st
 Briscoe, Wm., Inventor, 840 Cross st

Britton, J. B., Metal Chem., 239 Walnut st
 Broek, T. F., Plumber, 224 N. 4th st
 Brodie, Wm., Plumber's Casts, 15 N. 7th st
 Brognard, H. A., 1001 Chestnut st
 Brooks, David, E. E., Germantown, Phila.
 Brooks, Jas. C., 117 N. 33d st
 Brooks, Silas, M.D.
 Brothers, Chas., Hatter
 Brown, A., Soles, 2105 Germantown av
 Brown, Alex., Mer, 19th and Walnut sts
 Brown, Clark, Foreman, 1837 Market st
 Brown, David J., Germantown
 Brown, Edward, Eng, 311 Walnut st.
 Brown, F. A., Bkpr, 21st and Wash. av
 Brown, Frank P., Plumber, 53 N. 6th st
 Brown, Henry, Pattern Mkr, 250 N. 2d st
 Brown, John A., Jr., 19th and Walnut sts
 Brown, Lucien, Card Mkr, 227 N. 3d st
 Brown, Moses, Mer, 1120 Pine st
 Brown, Paul R., Stenog, 4483 Chestnut st
 Brown, Thos. R., S. W. cor 12th and But-
 tonwood sts
 Brown, T. W., Mfr. Ticking, 233 Chestnut st
 Brown, William, Mer and Mfr, 819 Arch st
 Brown, Wm. T., Electrician, 233 S. 4th st
 Browning, G. G., Mer, 14 N. Front st, Cam-
 den, N. J.
 Bryan, J. G., Plumber, 1219 Spruce st
 Bryan, T. M., Plumber, 1219 Spruce st
 Bryant, Edw., Woollen Overseer, 609 W
 Cumberland st
 Bryson, Jas. H., Printer, 500 N. 6th st
 Buckley, Geo. E., 903 Walnut st
 Buckley, W. Alex., Painters' Supplies, 1105
 Race st
 Budd, T. A., Jr., Lawyer, 212 Washington sq
 Budd, Walter J., Lawyer, 141 S. 6th st
 Buecker, A. E., Sugar Ref, 324 N. 5th st
 Bullock, Chas., Chemist, 528 Arch st
 Bullock, E. H., Teacher, 1753 Woodstock st
 Bullock, Jno. G., Chemist, 528 Arch st
 Bullock, Wm. A., Chemist, 1017 Clinton st
 Bunting, Chas. A., Draughtsman, care of
 Penn. Steel Co., Steelton, Pa.
 Burden, Clarence, Lawyer, 1715 Pine st
 Bargin, Jno. H., Mfr, 433 Arch st
 Burk, Addison B., Editor, *Ledger* Office
 Burk, Henry, Mach, 409 Arch st
 Burk, Wm. M., 306 Chestnut st
 Burke, E. M., 45 N. 17th st
 Burleigh, J. B., Author, 703 Market st
 Burnham, Geo., 221 Green st
 Burnham, Wm., 218 S. 4th st
 Burnside, Thos., Teacher, 1706 Vine st
 Burr, Edwin H., Lubricants, 125 N. 5th st
 Burr, Wm., M.D.
 Burr, Wm. H., Boiler Mkr, 126 Reed st
 Burton, Jno. A., Lawyer, 502 Walnut st
 Butler, Henry L., M.E., 1600 Hamilton st
 Butterworth, J., Tinsmith, York bel,
 Cedar st

Butz, Alfred L., Mfr, 829 N. 3d
 Buzby, Jos. H.
 Byrne, Daniel, Chemist, 1336 N. 11th
 Cadwallader, C. E., M.D., 240 S. 4th
 Camac, Wm. M., M.D., Wissahickon, Phila.
 Caldwell, Ezekiel, Eng, Box 22, Concord,
 Knox Co., Tenn.
 Caldwell, Jas., 211 Quarry st
 Camacho, L. A., M.E., 47 N. 2d st
 Cameron, Jno. M., M.E., 227 Moore st
 Camp, J. H., Lithographer, 349 N. 3d st
 Campbell, Arthur W., Mfr, Walnut Lane,
 Gtn.
 Campbell, F. E., M.E., N. E. cor 5th and
 Chestnut sts
 Campbell, J., Addison, Commission Mer-
 chant, Manayunk, Pa.
 Campbell, John H., 532 Vine st
 Canby, Geo., Plumber, 201 S. 13th st
 Canby, Henry P., 500 N. Broad st
 Canby, John, Plumber, Hoyt P. O., Mont-
 gomery Co., Pa.
 Canby, Wm. W., Clerk, Oak Lane P. O.,
 Philadelphia, Pa.
 Carbutt, John, Wayne Junction, Phila.
 Carl, M. F., 84 Oxford st, Providence, R. I.
 Carnell, John, Contractor, 2219 N. 6th st
 Carnell, W. F., Machinist, 1819 N. 5th st
 Carpenter, A. E., Mfr, 211 S. Front st
 Carpenter, Jas. H., Lawyer, Camden, N. J.
 Carr, Geo. W., M.E., 231 N. 12th st
 Carr, Joseph, M.E., 231 N. 12th st
 Carr, L. G., Mach, 2227 Trenton av
 Carriek, Wm. C., Baker, 1900 Market st
 Carson, R. D., 647 N. 35th st
 Carter, John E., Chemist, 24th and Bain-
 bridge st
 Cartwright, Henry R., 1028 Spruce st
 Cartwright, W., Oswego, N. Y.
 Carty, Jerome, Atty-at-law, 1405 N. 16th st
 Cassin, Isaac S., Eng, 1104 N. 12th st
 Catherwood, H. W., Mer, 1798 Walnut st
 Cawley, Samuel B., Bricklyr, 1413 N. 13th st
 Chabot, Cyprlan, Mach, 2516 Sharswood st
 Chambers, A. C., Grocer, N. E. cor. 5th and
 Pine sts
 Chambers, Cyrus, Jr., Mach, Wynnewood
 P. O., Pa.
 Chambers, F. T., 901 Walnut st
 Chambers, John S., Jr., C.E. P. O. Box
 217, Trenton, N. J.
 Champion, H. W., 2123 Mervine st
 Chandler, Jas. B., Printer, 143 N. 15th st
 Chapin, C. L., 2029 Carlisle sq
 Chapman, H. C., M.D., 1226 Walnut st
 Chase, Jas. A.
 Chase, R. L., Chemist, 1366 Sp. Garden st
 Cheney, Luther I., Mach, 226 Jacoby st
 Cheney, Waldron J., Silicites, 4301 Haver-
 ford av

- Chesshire, Caleb J., Supt Oil Tanks, 110 S. 33d st
 Chesterman, Edwin, Publisher, 3703 Barling st
 Chew, Sinnickson, Editor, Front and Market sts, Camden, N. J.
 Chew, Henry B., Supt Gas Works, 6 N. 7th st
 Cheyney, Joseph W., Philosophical Instructor, 649 N. 44th st
 Cheyney, Wm. A., Conveyancer, 15 S. 7th st
 Child, R. S., Jr., Law Studt, 901 Walnut st
 Childs, Geo. W., Publisher, 6th and Chestnut sts.
 Chorman, Chas. H. J., Lawyer, 727 Walnut st
 Christie, Jas., M. E., 261 S. 4th st
 Christy, Daniel, Pattern Mkr, 124 Queen st
 Christy, James
 Church, Arthur L., M. E., 500 N. Broad st
 Churchman, Chas. W.
 Claghorn, J. Raymond, 222 W. Logan sq
 Claghorn, Clarence R., M. E., Bernice, Sullivan Co., Pa.
 Clarenbach, Louis, 220 Church st
 Clark, Jno. G.
 Clark, J. Ross, Printer, 230 Dock st
 Clark, W. S., Plumber, 218 S. 12th st
 Clark, Wm. M., Engraver, 441 Chestnut st
 Clarke, Wm. H.
 Clarkson, Edw.
 Clarkson, Michael, Bkpr, N. E. cor Front st and Girard av
 Clarkson, R. C., Beverly, N. J.
 Clay, Clemens, Mach, 1018 Buttonwood st
 Clay, J. H., Mach, 703 N. 15th st
 Claxton, Edmund, 930 Market st
 Clegg, T. T., Bkpr, 7107 Woodland av
 Cliff, Geo. H., Prof. Central H. School, 911 N. 12th st
 Cline, Edw. H., Carpenter, 1002 Poplar st
 Close, Chas. W., Conveyancer, 331 Reed st
 Clothier, Jas., Mfr, 816 E. York av
 Cloud, J. Cooper, Agent, 1427 N. 17th st
 Clyde, Thompson, 2207 Madison sq
 Cobb, Geo. H., Kalion Chem Co., 31st and Grays Ferry rd
 Code, Theophilus, Meter Mkr
 Codman, Jno. E., Draughtsman, 3733 Spruce st
 Coffin, William, Camden, N. J.
 Coggeshall, Thellwell R., Mach, 1313 N. 23d st
 Coleman, Edw. E., Mer, 1909 Park av
 Coleman, Thos. H., C. E., 2135 Spruce st
 Coleman, Ezra, Lawyer
 Collins, Alfred E., Mer, 1518 Locust st
 Collins, A. T., Spices, 1206 Race st
 Collins, Chas. Russell, 727 Brown st
 Collins, Edw., Architect, 410 Walnut st
 Collins, Henry H., Cards, 103 S. 21st st
 Collins, Jas. M. D., 704 Franklin st
 Colton, O. B., C. E., 2009 Wallace st
 Colvin, H. F., M. E., 3906 Fairmount av
 Comer, Harris, Chem, 624 S. Washington sq
 Conard, Thos. P., Iron Fdr, N. W. cor 3d and Arch sts
 Connor, Edw., Student, 126 S. 18th st
 Constable, Stevenson E., Moorestown, N. J.
 Converse, John H., 500 N. Broad st
 Cook, J. E., Druggist, 426 Broadway, Camden, N. J.
 Cook, Wm. F., Carpenter, 1326 Franklin st
 Cooper, C. C., Clerk, 5581 Germantown av
 Cooper, David, Clerk, 410 Race st
 Cooper, Henry, Mgr, P. O. Box 511, Phila.
 Cooper, Jas. W., Cabinet Mkr, 1706 Wash. av
 Cooper, J. E., Mach, 17 S. 4th st
 Cooper, Jno., H., M. E., 135 Wistar st, Gtn.
 Cooper, Jos. B., Carpenter, 14 S. Broad st
 Cooper, Wm. B., Lawyer, 517 Locust st
 Cooper, Wm. S., Plumbers' supplies, 259 N. Broad st
 Cope, E. D., 2100 Pine st
 Cope, John O., Eng, 223 N. 11th st
 Cope, Marmaduke, Mer, 53 Penn st, Gtn.
 Copper, Jno. C., Tool Cutter, 15 S. 6th st
 Cornelius, Chas. E., Mfr, Riverton N. J.
 Cornelius, Harry R., Driftsmn, 4432 Gtn av
 Cornelius, J. C., Mfr, 1332 Chestnut st
 Cornelius, Robert, Lamp Mfr, 1027 Arch st
 Cornwell, C., Steam Fitter, 105 N. 4th
 Costigan, Thos., Jr., Contractor, 3115 Sp. Garden st
 Cotterrell, W. W., 107 Chestnut st
 Cottrell, C. B., Mfr, Westerly, R. I.
 Cottrell, E. H., Mfr Printing Presses, 8 Spruce st, N. Y.
 Couch, A. B., 21st and Callowhill sts
 Courtney, Geo. S., Furniture, 70 Herman st, Gtn.
 Cowden, M. A., 1424 N. 12th st
 Cowell, E. P., Mer, 22 S. 43d st
 Cox, F., Ship Joiner, 1404 Beach st
 Cox, Herbert, Philadelphia Club
 Cox, John
 Cox, J. Silgreaves, Eng
 Cox, Stephen C., Millwright, 2910 Poplar st
 Cox, Wm. P., Draughtsman, 206 N. 4th st
 Coxe, Brinton, Lawyer, 1711 Locust st
 Coxe, Eckley B., M. E., Drifton, Luzerne Co., Pa.
 Craig, Geo. S.
 Craig, Jno. G.
 Craig, Temple
 Cramer, Henry, E. Walnut Lane and Morton st, Gtn.
 Cramp, Chas. D., Ship Bldr, 1910 Park av
 Cramp, Chas. H., Ship Bldr, 1736 Sp. Garden st
 Cramp, Courtland D., Brass Fdr, 1736 Sp. Garden st
 Cramp, Henry A., Brass Fin, 1104 Collar st

Cramp, H. W., Clerk, 1700 Park av
 Cramp, Howard, Brass Fdr, York and
 Thompson sts
 Cramp, Jacob C., Ship Bldr, Beach and
 Norris sts
 Cramp, Samuel H., Ship Bldr, Beach and
 Norris sts
 Cramp, Wm. M., Ship Bldr, Beach and
 Norris sts
 Cravan, S. N., 1706 Wallace st
 Crease, Alfred
 Cressman, Philip, Teacher, 1623 Poplar st
 Cresson, Chas. C., Mer, 5003 Green st, Gtn.
 Cresson, Chas. M., M.D., 413 Locust st
 Cresson, G. V., Mach, 18th and Hamilton sts
 Cresswell, Samuel J., Iron Fdr, 23d and
 Cherry sts
 Crossdale, Edgar, 221 Carter st
 Crofut, G. W., Publisher
 Crosby, D. E., M.E., 805 Market st
 Cross, Geo. W., Iron Chests
 Crowell, J. W., Mach, 627 Elm st, Camden,
 N. J.
 Crumbaugh, J. W., M.D., 100 N. 15th st
 Culbertson, Thomas, 1600 Somerset st
 Cullen, Geo. S., Clerk, 421 Walnut st
 Cumming, J. K., 10th Nat. Bank, 13th and
 Columbia av
 Cummings, Robert A., Eng, 3414 N. 19th st,
 Tioga
 Cunningham, Francis A., C.E., 817 Arch st
 Currie, Stanley C. C., Electrical Eng, 1719
 Chestnut st
 Curtis, John, N. W. cor 17th & Cayuga sts

 Dale, John H., Draughtsman, 4109 Ogden st
 Ballett, Geo. A., Mach, N. W. cor 13th and
 Buttonwood sts
 Ballett, Thos. H., N. W. cor 13th and But-
 tonwood sts
 Ballett, Wm. P., Soaps, N. W. cor 13th and
 Buttonwood sts
 Dalton, Col. J. M., Inventor, 2129 N. 8th st
 Dashiell, B. J., Jr., 1334 Calhoun st, Balti-
 more, Md.
 Darrach, Chas. G., C.E., Ridley Park, Pa.
 Darrach, Francis L., Chemist, care Alfred
 Darrach, 49 S. 4th st
 D'Auria, L., 2030 Diamond st
 Davids, R. W., C.E., Merion Station P.O.,
 Phila.
 Davis, Courtland H., 1516 Girard av
 Davis, E. McC., M.E., 817 N. 8th st
 Davis, H. C., 32 Nassau st, New York City
 Davis, H. L., Oil Ref, Point Breeze
 Davis, H. T., 721 S. 24th st
 Davis, James G., Draughtsman, 1923 Car-
 penter st
 Davis, Wm. M., Chemist, Oak Lane P. O.,
 N. P. R. R.
 Davis, Wm. H., Mer

Davidson, Robert B., Broker, 313½ Wal-
 nut st
 Dawes, R., Mach, Schlichter's Mill, Erie
 st and Trenton av
 Day, R. H., 460 N. 2d st
 Day, W. C., Swarthmore College, Swarth-
 more, Pa.
 Dean, L. L., 3125 Powelton av
 DeBatalas, Victor, Chemist, 1308 Arch st
 De Bausset, A., M.D., 236 State st, Chicago,
 Ill.
 De Camp, A. J., Electr, 2005 Johnstone st
 Dechert, Henry T., Atty-at-Law, 3914 Wal-
 nut st
 Decker, Robert P., Atty-at-Law, 615 Wal-
 nut st
 Decker, Lizzie S., 1032 Race st
 D'Heureuse, R., Mfr, P. O. Box 395, N. Y.
 Deiterich, Emile F., 4221 Ludlow st
 De Lara, G. Lopez, M.E.
 Dalbert, Simon, Tallow, 1721 Arch st
 De Motte, J. B., Del'auw University, Green-
 castle, Ind.
 De Morat, O. B., Photography, 914 Chestnut st
 Dereum, Francis, M.D., 8th & Wallace sts
 Deschamps, F. O., 309 N. 9th st
 Desmond, Wm. C., Costumer, 917 Race st
 Deutz, A. Cornelius
 Devereux, W., 303 Madison av
 Devlin, Thos., Iron Fdr, American st and
 Lehigh av
 Dewees, J. W., Mach, 33 N. 7th st
 Dialogue, Jno. H., Ship Bldr, Broadway
 and Pine st, Camden, N. J.
 Dick, Evan R., 330 Walnut st
 Dickerson, Winchester, M.E., 3310 Walnut st
 Dickson, D. T., Steamship Bldr, 34 S. 2d st
 Dickson, Jas. F., Bk-Bdr, N. W. cor. 7th
 and Arch st
 Dickson, L. Taylor, 707 Walnut st
 Dillon, Eli, Plasterer, Ridge av & Green st
 Disston, Horace C., Saw Mfr, Front and
 Laurel sts
 Disston, Thos. S., Saw Mfr, Tacony, Pa.
 Dixon, E. S., Lawyer, 715 Walnut st
 Dixon, J. W., Paper Mfr, 1629 N. 15th st
 Dobbins, E. T., 1412 Walnut st
 Dobbins, R. J., 308 N. Broad st
 Dock, Clifford, Mach, 901 N. Broad st
 Dock, Herman, Supt, 901 N. Broad st
 Dodge, Wallace H., Mishawaka, Ind.
 Dodge, William, Mishawaka Ind.
 Doerr, C. A., 1419 Sp. Garden st
 Doll, Geo., Merchant, 319 Marshall st
 Dolley, C. S., Teacher, Univ. of Penna.
 Phila.
 Donaldson, Wm. J., Chemist, 226 Walnut st
 Donohugh, Wm. J., Clk, Roxborough, Phila
 Donovan, Daniel, 608 Market st
 Dougherty, E. D., Mrble Dlr, 1432 N. 20th st
 Dougherty, Jas., Mldr, 24th and Wood sts

Douglass, J. W., Atty-at-Law, 914 Walnut st
 Dow, Josiah, Mfr, 109 Rittenhouse st, Gtn.
 Dowdell, Abner W., Turner, 911 Vine st
 Downing, Richard H., 1613 Race st
 Doyle, Wm. H., Mstr Plmbr, 262 S. 15th st
 Drayton, Wm. Heyward, Lawyer, 704 Walnut st
 Dreer, Ferd. J., 1520 Spruce st
 Dresher, Geo. B., care of Chicago Edison Co., Chicago, Ill.
 Drown, W. A., Jr., Umbrella Mfr, 246 Market st
 Drysdale, Wm. A., M.D., 1531 Arch
 Du Bois, W. L., Treasurer, 421 Chestnut st
 Dudley, C. B., Chemist, Altoona, Pa.
 Dumee, E. S., Mer, 125 Chestnut st
 Dunbar, J. S., Mfr, 1602 Park av
 Dundore, Chas. R., 1623 Arch st
 Dundore, Franklin, Broker, Drexel Bldg
 Dundore, Nathan, Broker, Drexel Bldg
 Dunwoody, Chas., Mer, 1909 Market st
 Durang, Edwin F., S. W. cor 12th and Chestnut st
 Durfee, Wm. F., Arch and Eng, Birdsboro, Berks Co., Pa.
 Dwight, E. P., Hyd Eng, 407 Library st
 Dye, John H., Surv Pub, 706 Chestnut st
 Dykeman, F. W., Clerk, 619 Chestnut st
 Dyott, Chas. G., Lamps, 114 S. 2d st

Eakin, Constant M. I.
 Eastwick, J. H., Chem, Wissahickon Sta
 Eavenson, A. T., Mfr, 2013 Vine st
 Eavenson, M. M., Mfr, 313 N. 20th st
 Ebaugh, W. C., M.D., N. E. cor 38th and Lancaster av
 Eccles, J., Mach, Amber and Taylor sts
 Eckfeldt, J. B., Assayer, U. S. Mint
 Eisele, Gustave, Jr., Eng, 2238 N. 4th st
 Eisenbrey, F. A., 1916 Fell st
 Elder, Geo. R., Draughtsman, 1237 Arch st
 Eldridge, G. Morgan, Lwyr, 798 Walnut st
 Elkins, G. W., 423 Walnut st
 Elkinton, Alfred C., Mfr, 817 Mifflin st
 Elkinton, Joseph, Mfr, 817 Mifflin st
 Elkinton, Jos. S., Mfr, 325 Pine st
 Elkinton, Thos., Mfr, 17 S. Front st
 Elliott, Jas. A., Painter, 39 N. 7th st
 Ellis, Wm. H., Carpenter
 Elverson, J., Publisher, 9th and Spruce sts
 Ellwell, John K., Salesman, 21 S. Front st
 Ely, Theo. N., C.E., Altoona, Pa.
 Emanuel, J. M., P. Asst. Eng. U.S.N., U.S.S. Ajax, Richmond, Va
 Emerick, John A., Foundry, 1056-1076 Beach st
 Emlen, Geo. W., Mfr, Germantown, Phila.
 Emory, John, Farmer, Cheltenham, Pa.
 Engel, Theo. C., Brewer, 9 S. 7th st
 Engle, R. H., Clerk, 226 S. 5th st
 English, Jacob C., Plasterer

Enochs, John, Builder, 1930 N. 7th st
 Engard, Albert C., P. Asst. Eng. U. S. N., 837 N. 26th st
 Ennis, Prof. J., Principal
 Erben, Henry, Mfr, 2416 Sp. Garden st
 Erben, Walter, Mfr, 3415 Baring st
 Errie, Henry, Mfr, 238 N. 12th st
 Ersty, Wm.
 Estlack, Chas. E., Bricklayer, 119 S. 18th st
 Estrada, Raphael, Eng, 1012 Passyunk av
 Evans, C. Albert, 1633 S. Broad st
 Evans, D. Z., Real Estate Broker, 618 Sp. Garden st
 Evans, Geo. B., 861 N. 7th st
 Evans, J. B., 226 Walnut st
 Evans, Wm. P., Drftsman, 500 N. Broad st
 Everett, Wm., Eng, Rye, N. Y.

Fagan, Geo. R., 253 N. 18th st
 Fagerstrom, A. W., Mach, 2139 Master st
 Fairbanks, C. H., Printer
 Falkenau, Arthur, Eng, 3214 Spencer Terrace
 Fallows, Jas., Mfr, 714 N. 44th st
 Farren, B. N., Mfr, 1731 Sp. Garden st
 Faser, C., Frame Mkr, 824 Arch st
 Faught, G. G., M.D., 115 N. 15th st
 Faught, L. R., Supt, 1220 N. 18th st
 Fanser, J., Mach, 2216 Orianna st
 Fearon, Chas., Salesman, 1618 Mt. Vernon st
 Febiger, C. C., Philadelphia
 Febiger, Kath. S., Philadelphia
 Feehtig, John, 1120 Girard st
 Feister, H. P., C.E., Room 9, 420 Library st
 Fell, J. R., Coal, 237 S. 3d st
 Felt, A. B., Agt Davis S. M. Co., 1223 Chestnut st
 Fenton, J. H., Mfr, 407 N. 2d st
 Ferguson, Jos. C., Eng, 522 Walnut st
 Ferguson, Wm. S., Chemist, P.O. Box 1008
 Fernie, John, C.E., 113 S. 40th st
 Ferree, Samuel P., Pblshr, 1104 Walnut st
 Ferrell, Wm., Mach, 1010 Shackamaxon st
 Fesquet, A. A., Chemist and Engineer, 1322 Marshall st
 Field, Chas. J., Hardware, 633 Market st
 Field, Walter D., Chemist, Short Hills, N. J., care Ind. Crane Chemical Co.
 Figanieri, A. de, Metallurgist, 1125 Fairmount av
 File, John C., Merchant, 421 Market st
 Finck, Chas. W., Student, 1120 Girard st
 Finck, Edw. B., Student, 1120 Girard st
 Firmstone, Wm.
 Fisher, Jacob L., 1516 Swain st
 Fisher, Jos.
 Fisher, R. A., Chemist, 2239 St. Alban's pl
 Fisher, Wm. R., Lawyer, 330 Walnut st
 Fiss, G. W., Worsted Mfr, 106 Chestnut st
 Fitch, Henry W., Chief Eng. U.S.N., 3939 Chestnut st

Fitler, Edw. H., Mfr, 23 N. Water st
 Fitzgerald, P. J., Gas Eng, 111 N. 4th st
 Fitzpatrick, T., Builder, 2217 Chestnut st
 Flagg, Stanley G., Jr., Mfr Mal Castgs,
 19th st and Pennsylvania av
 Flanagan, C. L., 429 S. Delaware av
 Flanagan, L. A., 429 S. Delaware av
 Flanagan, Stephen, 120 S. Delaware av
 Fleming, Otto, Elec Ins, 1009 Arch st
 Fleming, W. A., Metal Ref
 Flemstrom, A. O., Well borer, 913 Kurtz st
 Fodell, Wm. P., Secretary, 50 Laurel st
 Foell, Franklin, 1006 S. 17th st
 Fondersmith, H., Station Oprtr, 32d and
 Market sts
 Formad, H. F., M.D., 35th and Locust sts
 Foster, Chas. E., Clerk, 1233 Chestnut st
 Foster, H. A., Elec Light Expert, care of
 East River Elec Light Co., 421 E. 24th st,
 New York City.
 Fouché, W. W., Dentist, 239 N. 6th st
 Foulke, Jno. F., Atty-at-Law, 1827 Pine st
 Fowler, Horace N., Chrpdst, 1123 Arch st
 Fowler, J. A., N. W. cor 4th & Walnut sts
 Fowler, Philip H., Mfr, Gloucester, N. J.
 Fox, Samuel L., Optician, 924 Chestnut st
 Fraiser, James, Carpenter, 331 Pine st
 Fraley, Frederick, Prsdnt, 1000 Walnut st
 Fraley, J. C., 1833 Pine st
 Francis, H. C., 1732 Master st
 Franklin, Benjamin, C.E., 1710 N. 18th st
 Frazer, Dr. Persifor, Geologist, Room 1042,
 Drexel Building
 Frazer, Robert, Eng, 209 S. 3d st
 Frederick, Montgomery L., Engraver, 153
 S. 4th st
 Freeman, Harold A., C.E., 422 Walnut st
 Freeman, James, Carpenter, 544 Federal st
 Freist, H. C., Chemist, 2323 St. Alban's pl
 Fricke, A., M.D., 235 N. 6th st
 Frings, Dr. C. H., 616 Lexington av, N. Y.
 Fry, Jacob W., 908 N. 5th st
 Fry, Mason K., Plumber, 728 Sp. Garden
 st
 Fry, Paul Jones, Ins Broker, 1734 Mt. Ver-
 non st
 Fryer, G. G., Mgr, 1704 Race st
 Fuller, A. F., Student, 218 N. 2d st
 Fuller, A. H., 218 N. 2d st
 Fuller, Allen J., Draughtsman, 13th and
 Sp. Garden sts
 Fullerton, Spencer, 1325 Spruce st
 Furman, S. T., Carpenter, 1713 Girard av
 Furness, Howard H., 7th and Locust sts

Gardiner, Richard, M.D., N. E. cor. 17th
 and Arch sts
 Gardiner, Wm. D., Car Bldr, 214 S. 5th st
 Garner, Anthony, Mach, Ashland, Pa.
 Garrett, James, Mach, 140 N. 3d st
 Garrett, Caspar S., Paper Mfr, 12 Decatur st
 Garrett, S., Paper, 3 Decatur st
 Garrett, Sam'l H., Millwright, 3610 Melon
 st
 Garrett, Wm. E., Jr., Mer, 221 S. Front st
 Garrigues, S. S., Chemist, Ann Arbor
 Garrigues, D. Whitall, Bkpr, Woodbury,
 N. J.
 Garrison, F. Lynwood, Eng, Radnor, Dela-
 ware Co. Pa.
 Garrison, Wm. X., 517 Cooper st. Camden,
 N. J.
 Garsed, Richard, Mfr, Frankford
 Gartley, Jos. C.
 Garver, M. M., Chester and Maple sts
 Gates, Marcus A., Salesman, 630 Locust st
 Gawthrop, Henry, Coal, 311 Walnut st
 Gemrig, J. H., Surg Inst, 109 S. 8th st
 Genth, F. A., Chemist, 1212 Fairmount av
 Genth, F. A., Jr., Chem, 4014 Chestnut st
 Gerker, Henry, Mfr.
 Gerlach, Henry, Watch Mkr, 2631 German-
 town av
 Gerlach, Wm., Banker, 816 N. 7th st
 Ghriskey, Chas. M., 508 Commerce st
 Gibson, J. Howard, M.E., 2001 Walnut st
 Gieseler, E. A., Lt.-House Eng, P. O. Box
 3678, New York City
 Gifford, Elton B., Mer, 719 Market st
 Gilbert, John W., Mach, 1826 Hamilton st
 Giles, Joel, Lawyer, Boston, Mass.
 Gill, H. B., Lawyer, 518 Walnut st
 Gill, John L., Jr., M.E., 503 Woodland Tree
 Gilpin, Chas., Lawyer, 636 S. 13th st
 Gilpin, Geo., Broker, 312 S. Broad st
 Gilpin, Richard W., Electrician, 1332 Pine st
 Glasgow, A. G., M.E., 333 Walnut st
 Glass, Dr. Jas., Electrician, 1210 Filbert st
 Glavin, J. Benjamin, Soap Mkr, 817
 Millin st
 Gleason, Wm., Millwright 4925 Girard av
 Glessner, Oliver P., Printer, 1732 N. 8th st
 Glover, Henry, Chemist, care of Powers &
 Weightman, E. Schuylkill Falls.
 Golchewitz, R., Type Fder, 608 Sansom st
 Gobrecht, Wm. H.
 Godwin, H., 3108 N. 19th st
 Goforth, Edmund, Saw Maker, 133 Rich-
 mond st
 Goforth, Samuel, Carver, 2012 N. 20th st
 Goldsborough, John, Mfr Stamps, General
 Delivery, P.O.
 Goldschmidt, T. J., 3338 Frankford av
 Goldsmith, E., Chemist, 658 N. 10th st
 Goldsmith, Martin, 2d and Vine sts, Cam-
 den N. J.

- Good, Jas., Soap, 415 Dillwyn st
 Good, W. E., Reading, Pa.
 Goodchild, Edward, 1522 S. 9th st
 Goodman, Geo., Printer
 Goodwin, S. A., Eng, 1617 Poplar st
 Goodwin, Samuel W., Restaurateur, 243
 Mechanic st, Camden, N. J.
 Goodwin, W. W., Meters, 1016 Filbert st
 Gordon, Frederick W., Eng, 226 Walnut st
 Gordon, James G., Atty-at-Law, 227 S. 6th st
 Gorgas, John, Miller, Roxborough, Pa.
 Gould, Theo., Student, 723 Erie st
 Gowen, Franklin B., Lawyer, 204 S. 4th st
 Graf, J., Mach, 1309 N. 9th st
 Graff, Albert, Mer, 3606 Chestnut st
 Graff, Frederick, C.E., 1337 Arch st
 Gracff, Geo. W., Jr., Journalist, Drexel
 Building, 5th and Chestnut sts
 Graham, W. M., Eng., 2015 Brandywine st
 Grahame, I. J., Pharmacist, 29 N. 12th st
 Gramlich, Geo. A., Stone Msn, Hutchinson
 st and Girard av
 Granger, A. O., Mach, Drexel Bldg
 Grant, Jas. W., Eng, 715 Chestnut st
 Grau, P. J., Mach, 921 Filbert st
 Graver, E. S., Mer, 209 N. Front st
 Gray, Henry W., Piano Mfr, 1103 Chestnut st
 Gray, Jas. Gordon, care of Queen & Co, 924
 Chestnut st
 Gray, Robert C., Bkpr, 1540 N. 7th st
 Greble, Edwin, Jr., 1708 Chestnut st
 Greene, Albert S., Colonnade Hotel, Phila.
 Greene, W. H., Chemist, 204 N. 36th st
 Greene, Francis V., M.D., 39 S. 19th st
 Greenhalgh, R. C., Mach, 103 E. Harrison
 st, Frankford
 Greenleaf, O.C., Mech, Belleville, Ont., Can.
 Greer, Thos., Mach
 Gregory, Wm. J., Clerk, 24 N. 4th st
 Grier, John A., Eng, P. O. Box 743, North
 Adams, Mass.
 Grier, M. J., M.D., 1531 Spruce st
 Griffith, A. E., M.D., 43 S. 3d st
 Griffith, R. Eglesfeld, Atty-at-Law, 2203½
 St. James pl
 Griffiths, W. S., Ambler, Montgom'y Co., Pa.
 Grimshaw, C. O., M.E., Wilmington, Del.
 Grimshaw, Robert, M.E., 169 Broadway,
 N. Y.
 Griscom, Jos. W., Chem, Jenkintown, Pa.
 Griscom, W. W., Electrician, 224 Carter st
 Gross, H. S., M.D., 1433 S. 6th st
 Grove, J. Ross, E.E., 1406 Chestnut st
 Grumbes, Samuel W.
 Gummey, W. T., Mer, 1023 Market st
 Gumpert, B. B., M.D., 840 Franklin st
 Gutekunst, F., Photographer, 712 Arch st
 Haag, Wm., 447 N. 9th st
 Habel, J. M., Teacher, 53d st & Girard av
 Hacker, Wm., Agr Imp, 161 Wistar st, Gtn.
 Haddock, D., Jr., 426 Walnut st
 Haenichen, Otto, Supt, 213 Manheim st,
 Gtn.
 Haedrich, Edw. M., Com Agt, 311½ Wal-
 nut st, Room 11.
 Haefelfinger, C. C., Pblshr, 3731 Spruce st
 Hahman, F., Harrowgate st, Phila.
 Haines, A. W., Carpenter, 1513 Marshall st
 Haines, Henry, Surveyor, 517 Walnut st
 Haines, Henry C., Germantown, Pa.
 Haines, J. S., Germantown, Pa.
 Haines, Miss J. R., Germantown, Pa.
 Haines, Reuben, 123 Chelten av, Gtn., Pa.
 Haines, Robert B., Cheltenham, Pa.
 Haines, Robert B., Jr., 1312 Filbert st
 Haines, W. A., Mfr, 1712 Green st
 Haines, Wm. J., 1312 Filbert st
 Hall, Augustus R., Mer. 709 Market st
 Hall, Chas. R., Iron Expert, Merchant-
 ville, N. J.
 Hall, Geo. W., Sec, 1131 Arch st
 Hall, Jas. T., Mach, 2321 Almond st
 Hail, John, Mach, 1234 N. 41st st
 Hall, L. B., Haverford College, Pa.
 Hallam, D.W., Merchant, 2d and Market'sts
 Hallowell, C. F., Grocer, 723 N. 16th st
 Hamilton, Robt., Care of Harrison Bros. &
 Co. Chemical Works
 Hamilton, W. C., M.D. 1700 Franklin st
 Hamilton, Wilbur F., Mfr of Paper, Rox-
 borough
 Hamrick, Harry, Jeweler, 804 Chestnut st
 Hance, Edw. H., Chemist, Germantown, Pa
 Hand, Alfred, Clerk, S. E. cor. 3d and
 Walnut sts
 Hand, S. Ashton, Mach, Lock Box 962,
 Philadelphia
 Hand, T. C., Jr., Clerk, 1811 Vine st
 Handy, E. Smith, Mer, Fox Chase, Phila.
 Handy, H. H. S., C.E., Fox Chase, Phila.
 Hansell, Wm. H., Jeweler, 1008 Chestnut st
 Hanson, H. Cooper, 3 Logan Square
 Harbach, T. J., Music, 809 Filbert st
 Harding, Geo., Atty-at-Law, 901 Walnut st
 Harding, W. W., 10th and Chestnut sts
 Hardwick, H., Carpet Mfr, 2017 E. Cumber-
 land st
 Hare, Hobart A., M.D., 117 S. 22d st
 Harkness, Wm., Plumber, 247 S. 3d st
 Harkness, Wm. J., C.E., 1909 Tioga st
 Harkness, Wm. W., Oil Mer, 324 Walnut st
 Harley, Wm. G., Miller, Minneapolis.
 Minn.
 Harley, Harry M., Ancora Print Works,
 Gloucester, N. J.
 Harned, Frank P., Clerk, Chemical Works,
 Washington av above 13th st
 Harper, Wm., Jr., Bricklry, 623 Federal st
 Harrington, E., Mach, 524 N. 18th st
 Harris, Geo. S., Printer, Arch above 7th st
 Harris, T. A., Dyer, 1303 Hancock st

Harrison, A. C., Sugar Ref, 101 S. Front st
 Harrison, G. L., Mer, 1704 Locust st
 Harrison, Jno., Mer, 1628 Locust st
 Harrison, Thos. R., Mach, 1923 Brown st
 Harrison, W. W., Sugar Ref, Almond st
 above Delaware av
 Hart, S., Bricklayer, 1104 Wallace st
 Hart, Wm. R., Iron Mer, 3301 Arch st
 Hartley, Henry J., Foreman Boiler Shop,
 1420 N. 7th st
 Hartman, J. M., Mach, 1237 N. Front st
 Hartman, John, Jr., Nickel Plater, 37 N.
 7th st
 Hartshorne, Chas., President, 228 S. 3d st
 Hartshorne, H., M.D., Hancock st, Gtn.
 Harvey, Alex. E., 226 S. 19th st
 Harvey, John L., Mfr, 910 N. 8th st
 Harvey, J. G., Terra-Cotta Pipe, 620 Arch st
 Hashall, Carroll J., Eng, 2118 Bain-
 bridge st
 Haslam, John G., M.E., 1942 Mascher st
 Hastings, Jas. L., Mining R.E., 302 Wal-
 nut st
 Hatfield, Walter, Mfr, 800 Richmond st
 Haug, J., M.E., 206 Walnut pl
 Haupt, Prof. L. M., C.E., University Pa.
 Hawkins, Ida V., Teacher, 4029 Fair-
 mount av
 Hayden, James, Mfr Men's Fur, 38 S. 6th st
 Heacock, Jos. H., Carpenter, 420 Tenot pl
 Heald, E. W., 503 Delaware av, Wilming-
 ton, Del.
 Heiss, Wm. J., Grocer, 956 Shackamaxon st
 Heller, C. S., S. E. cor Ridge av and Sp.
 Garden st
 Heller, Chas. G., Leather Dresser, 923 Hut-
 chinson st
 Heller, C. Nevln, 1120 Girard st
 Heller, G. M., Engr, 853 N. 20th st
 Hellings, A. J., M.E., 2123 Carlisle st
 Helme, Wm. E., Gas Meters, 1719 Vine st
 Hemperly, F.H., Phonographer, Phila. P.O.
 Henderson, Prof. C. Hanford, Man. Train-
 ing School, 17th and Wood sts
 Henderson, Edward, Hatter, Haddonfield,
 N. J.
 Henderson, John W., M.E., 1306 Arch st
 Hendrickson, Edw. D., Mach., 1840 N. 20th st
 Hendry, J. A., Leather Mer
 Henry, Geo. H., Salesman, 236 Chestnut st
 Hensell, Geo. F., Mfr, 119 S. 39th st
 Henszey, Jos. G., Pres't, 216 S. 4th st
 Henszey, S. A., C. E., 216 S. 4th st
 Henszey, Wm. P., M.E., 500 N. Broad st
 Hering, Carl, E.E., 3816 Sp. Garden st
 Herlug, Rudolph, C.E., 31 Chamber st
 (Room 19), N. Y.
 Herwig, Emilius, Apothecary, 3d and
 Brown sts
 Hess, Ell, Cutter, 32d st and Ridge av
 Hess, John A., Mach., 3120 Sp. Garden st

Heston, T. Z., Clerk P.R.R., 233 S. 4th st
 Hetzel, H. V., Opt Ins, 433 Magnolia st
 Hewett, G. W., Architect, 310 Chestnut st
 Hewlett, Chas. W., 853 N. 12th st
 Hewston, G., M.D.
 Hexamer, Chas. A., Ins Surv, 848 N. 24th st
 Hexamer, C. J., C.E., 2313 Green st
 Heyl, H. R., Mfr, 1050 Aspen st
 Heyl, Lewis, U. S. Appraiser-General, 4052
 Aspen st
 Hibbs, J. M., Mfr, 1320 Buttonwood st
 Hickman, John R., Clerk, s Walnut st
 Hicks, Thos. L., Supt, 65th & Hamilton sts
 Hildebrand, Wm., Confections, 1101 Vine st
 Hill, Rufus, Master Mech C. and A. R. R.,
 Camden, N. J.
 Hill, Geo. H., Clerk, care of Drexel & Co.,
 5th and Chestnut sts
 Hiller, Samuel N., Tel Oprtr, 3417 Mt. Ver-
 non st
 Hillman, Chas. L., Draughtsman, Upsal st
 near Main, Germantown
 Hildebrand, E., 325 Birch st, Camden, N. J.
 Hines, Jos. H., 40 N. 39th st
 Hines, Louis B., 40 N. 39th st
 Hines, John, Dials, 40 N. 39th st
 Hinkle, W. M., M.E., 1306 Sp. Garden st
 Hird, Samuel, Secretary, Mt. Pleasant av,
 Mt. Airy, Germantown
 Hobart, Jas. F., Cor Am Mech, 96 Fulton
 st, N. Y.
 Hockley, Wm. Stevenson, 235 S. 21st st
 Hoehle, C., Draughtsman, 2046 Carlisle st
 Hoehn, Conrad, Engr, 327 Crown st
 Hoffman, J. W., G. and M.E., 259 S. 17th st
 Hofstetter, Geo., Mfr, 719 Vine st
 Hohenadel, John, Jr., Mach, 2830 Girard av
 Holbrook, Stephen, Engr, 55 S. 3d st
 Hollingsworth, P., Druggist, 19 N. Front st
 Hollingsworth, Samuel S., Lawyer, 714
 Walnut st
 Hollis, P. C., Accountant, 407 Library st
 Holman, D. S., Tester, 108 S. 33d st
 Holmes, Seth C.
 Holmes, Wm., Mill Supt, 1014 Columbia av
 Holt, C. H., Mach, 714 Wallace st
 Hooker, Sam'l C., Chemist, 701 S. Front st
 Hoopes, Benjamin, Librarian, 8th and
 Spruce sts
 Hoopes, D. S., 1126 Girard st
 Hooven, J. Henry, Iron Mfr, Norristown, Pa
 Hopkins, S. D., Clerk, Mt. Airy, Pa.
 Hopper, Thos. C., 33 W. Walnut Lane, Gtn.
 Horne, C. H., Mer, 1818 Green st
 Horstmann, F. O., Mfr, 5th and Cherry sts
 Horstmann, W., Mfr, 5th and Cherry sts
 Horstmann, W. H., 108 S. 21st
 Hoskin, John, M.E., 308 Walnut st
 Hoskins, John, 231 N. 11th st
 Hoskinson, J. T., Jr., Druggist, 2000 N
 Front st

- House, H. J., 337 N. 9th st, Camden, N. J.
 House, John, Blacksmith, 17 Seltzer st
 Houston, Prof. E. J., 1521 Mt. Vernon st
 Houston, J. F., C.E., Columbia, Pa.
 Howard, C. Wm., Inventor, 1234 N. 15th st
 Howard, G. C., Machinist, 13 S. 18th st
 Howard, Wm. H., 3501 Hamilton st
 Howe, Arthur W.
 Howe, H. M., M.D., 1606 Locust st
 Howell, Joshua R., Farmer, 3404 Spring Garden st
 Howell, W., Paper Mfr, 12 S. 6th st
 Howell, Z. C., Paper Mfr, 12 S. 6th st
 Howson, Henry, Atty-at-Law, 119 S. 4th st
 Hughes, James, Mfr, 206 West Orthodox st, Frankford
 Hughes, Wm. B., Mfr, 141 N. Front st
 Hughes, Wm. H., Mfr, 141 N. Front st
 Humbert, Alfred, Watch-cases, 1744 N. 22d st
 Hunsicker, H. R., Produce, 1023 Fairmount av
 Hunt, Jos., Mfr, Iron and Coal Co., Emporium, Pa.
 Hunter, H., Gas Fitter, 55th & Paschall st
 Hunter, J., Calico Printer, 55th and Paschall sts
 Hunter, Jas. J., Yarn Mfr, 55th and Lancaster av
 Hunter, J. C., Plumber, 1150 S. Broad st
 Hunter, Rudolph M., Pat Sol, N. W. cor 9th and Walnut sts
 Hunter, Thos. G., 55th st and Lancaster av
 Hunter, Wm. D., 55th and Lancaster av
 Husband, John J., Carpenter, 2329 Fox st
 Huston, Chas., M.D., Coatesville, Pa.
 Hutchinson, A. H., 413 Walnut st, Room 20
 Hutchinson, C. H., 1620 Walnut st
 Hutchinson, Edward S., C. and M.E., Newtown, Pa.
 Hutchinson, Israel P.
 Hutchinson, Pemberton S., 1835 Pine st
 Hutchinson, Robert, Notary, 124 S. 6th st
 Huttinger, J. W., Teacher, Beverly, N. J.
 Hutton, Finley, Builder, 400 Chesnut st
 Hyzer, J. W., Brick-maker, 1506 N. 10th st
- Illman, Chas. T., Plate Printer, 605 Arch st
 Illman, Edward, Engraver on Steel, 1844 N. 13th st
 Illman, Edw. T., Letter Engraver, 1844 N. 13th st
 Ingham, W. A., President Tamaqua Co., 320 Walnut st
 Ingram, Wm. H., Mfr, 206 N. 3d st
 Insinger, Alfred, Mach, 4263 Gtn. av
 Iredell, G. S., Telgr Oprtr, 3926 Brown st
 Irwin, Agnes, Teacher, 1835 Spruce st
 Irwin, J. H., Morton, Delaware Co., Pa.
 Ives, Fred E., Photographer, 2750 N. 11th st
 Ivins, A. B., Teacher, 1524 N. Broad st
 Ivins, Wm., Carpet Mfr, 1539 N. 15th st
- Jackson, G. F., Carpenter, Box 432, Palatka, Fla.
 Jackson, Walter M., M.E., 19 Park Place, N. Y.
 Jahn, F. G., M.E., 20 St. Marks Place, N. Y.
 James, Bushrod W., M.D., 18th & Green st
 James, C. G., 1332 Washington av
 James, Samuel, Mach, 519 N. 43d st
 James, Walter M., M.D., 1123 Spruce st
 Janney, B. S., Jr., Grocer, 123 Market st
 Janney, Morris P., Asst Supt, Easton, Northampton Co., Pa.
 Jarvis, Jno. W., Salesman, 36 N. 38th st
 Jayne, E. C., Druggist, 242 Chestnut st
 Jayne, H. W., Frankford, Phila.
 Jayne, Horace, M.D., 1826 Chestnut st
 Jeanes, J. T., Mer, 1023 Arch st
 Jeffreys, Wm., Blacksmith
 Jenks, B. H., Mach, 319 Willings Alley, Room 6
 Jenkins, T. W., 2425 Nicholas st
 Jennings, W. H., M.E., 1224 Moyamensing av
 Jennings, Wm. N., Phonographer, 1302 Butler st
 Jessup, Alfred D.
 Jiencke, George, Mach, 1409 N. 4th st
 Johnson, Charles, 307 Walnut st
 Johnson, Chas. E., Ink Mfr, 500 S. 10th st
 Johnson, Chas. H., 3720 Hamilton st
 Johnson, E. H., Mach, 3720 Hamilton st
 Johnson, Geo. F., M.D., 608 Spruce st
 Johnson, Geo. L.
 Johnson, Geo. R., Tinsmith, 853 N. 8th st
 Johnson, Henry, Mach, 1222 Brown st
 Johnson, I. H., Jr., 1422 Callowhill st
 Johnson, J. E., P. O. Box 1155
 Johnson, Joshua R., 1422 Callowhill st
 Johnson, R. E., C.E., 3204 Race st
 Johnson, Wm. Shaler, 608 W. 7th st, Chester, Pa.
 Jones, Alexander H., Chemist, care of Powers & Weightman, 9th & Parrish sts
 Jones, Alfred, Norfolk House, Roxbury, Mass.
 Jones, D., Comptroller, 227 S. 4th st
 Jones, Geo., Teacher
 Jones, G. S. P., Mrs., 1312 Filbert st
 Jones, Geo. W., Clerk, 1328 Spruce st
 Jones, Jas. Cecil, Drftsmn, Pencoyd Iron Works, Pencoyd, Pa.
 Jones, Jas. F., M.E., 227 S. 4th st
 Jones, Nathan F., C.E., Room 95, 71 Broadway, N. Y.
 Jones, Owen, Iron Fdr, Media, Pa.
 Jones, Thos. B., Mer, 625 Market st
 Jones, Thos. W., 1600 Hamilton st
 Jones, Walter, Plumber, 626 Master st
 Jones, Warner C., Hrdwre, 2824 Girard av
 Jones, Washington, Steam Eng, Richmond and Ball sts

Jones, Wm. F., Merchant, Hotel Lafayette
Jordan, John, Jr., Mer, 1428 Spruce st
Justi, Henry D., Dentist, 1301 Arch st
Justice, Wm. W., Wool, 122 S. Front st

Kaighn, Robert, Bricklayer, Front and
State sts, Camden, N. J.

Keefer, Wm. B., 1608 N. 15th st
Keeley, Jerome, Tin Plate, 206 Walnut pl
Keiffer, A. R., Div Oprtr, Harrisburg, Pa.
Keinath, W., Furrier, 16th and Girard av
Keiser, E. H., Chem, Bryn Mawr College
Keller, Harry F., 257 N. 6th st
Kelley, Henry H., Druggist, 739 N. 26th st
Kelley, John W., Jr., Haddonfield, N. J.
Kelley, Hon. Wm. D., Atty-at-Law, Myrtle
and 41st sts

Kelly, Albert J., Inspector, 937 N. 11th st
Kelly, F. B., Tel. Oprtr, 326 New st
Kendall, Prof. E. O., Teacher, Univ. Pa.
Kennedy, Elias D., Broker, 308 Walnut st
Kennedy, John H., R.R. Supplies, 12 S.
4th st

Kennedy, R. G., 735 Walnut st
Kennedy, S. R., Mfr, 108 N. 5th st
Kent, Robt. S., Drftsman, 701 S. Front st
Ketterlinus, Jno. L., Lithographer and
Printer, 4th and Arch sts
Kiersted, A. J., Chief Eng U.S.N., 1728
Park av

Kihn, G. A., Bkpr
Kile, John, Pattern Mkr, 803 N. 17th st
Kille, John T., Treasr, 1822 Green st
King, Mills, Bricklayer, 1513 Fairmount av
King, Thos., Carpenter
King, Wm. T., Clerk, Camden, N. J.
Kingsbury, C. A., M.D., 1119 Walnut st
Kinsey, Wm., Jr., Morocco Mfr, 3d and
Vine sts

Kintner, C. J., Pat. Sol, 919 Chestnut st
Kircher, W. F., P. O. Box 640, Phila.
Kirchner, F., Mach, 1317 Park av
Kirk, Geo. H., Accountant, 1601 Callow-
hill st

Kirk, J. J., Clerk, 303 Walnut st
Kirkbride, Eliza B., 3395 Race st
Kirkbride, Dr. J. J., 35 S. 19th
Klapp, Jos., M.D., 622 Spruce st
Klander, J. C., Miller, 1913 N. 6th st
Knapp, C. M., 417 Walnut st
Kneass, Strickland L., Mach, 413 S. 15th st
Knight, Daniel R.

Knight, E. C., Mer, 1605 Chestnut st
Knight, Hartley, Mer, 1222 Chestnut st
Knight, J. Harmer, 1530 Marshall st
Knorr, J. Francis
Knowles, Wm. H., 209 N. Front st, Cam-
den, N. J.

Koenig, Geo. A., Prof. Chem, Univ. Pa.
Koeher, Geo. H., Electrician, Box 346, S.
Bethlehem, Pa.

Kohler, Ignatius, Bookbinder, 911 Arch st
Kolb, H. M., M.E., 2207 Venango st
Kramer, Henry, 1353 Palmer st
Krider, Peter L., Silversmith, 618 Chest-
nut st

Kuehn, R. E., Mach, 927 Gibbert st
Kuhn, Chas., Broker, 1712 Spruce st
Kuhn, C. Hartman, Broker, 1712 Spruce st
Kuhn, Hartman, Jr., 240 Walnut st

Ladner, Louis J., Banker, 503 Chatham st
Laing, Henry M., Shoe Findings, 335 N.
11th st

Lake, Vincent F., M.E., Pleasantville, N. J.
Lamb, Wm. W., M.D., 1247 Hanover st
Lambdin, Jas. R., Artist, 1224 Chestnut st
Lambert, Abram L., Tinsmith, 1864 Frank-
ford av

Lambert, John, Atty-at-Law, 420 Walnut st
Lambert, Richard, Tinsmith, 1864 Frank-
ford av

Lambert, S. C., Oil, 907 Sp. Garden st
Lamborn, R., 32 Nassau st, N. Y.
Lance, W. L., Mechanic, Whitings, N. J.
Langell, F. W., Mach, 23 York st, Clevel-
land, O.

Langenhein, F. D., Sgr Ref, 2012 Canaest
Large, Daniel, Eng, Poplar st above 2d
La Roche, F. A., Supt, 4927½ Main st, Gtn.
Larkin, Frank J., Rigger, 742 S. 15th st
Latimer, Geo. A., Clergyman, 989 N. 5th st

Latimer, Geo. A., Jr., Clerk, 989 N. 5th st
Latimer, Thos., Lawyer, 118 S. 7th st
Lauderbach, H. Y., Teacher, 108 S. 10th st
Laureau, L. G., Eng, 917 Walnut st

Lea, Arthur H., Publisher, 706 Sansom st
Lea, Francis H., Publisher, 2000 Walnut st
Lea, Henry C., Publisher, 2000 Walnut st
Lea, M. Carey, Atty-at-Law, 426 Walnut st
Leavitt, E. D., M.E., 604 Main st, Cam-
bridgeport, Mass.

Le Bontillier, Robert, Mer, Germantown
Leeche, Phillip P., 1027 W. York st
Leclerc, Francis, C.E., 824 N. 6th st

Le Conte, John, M.D., 1625 Spruce st
Ledig, R. G., Electro Plater, 821 Cherry st
Lee, Geo. Burtis, 533 N. 6th st
Lee, Geo. F., Builder, 533 N. 6th st

Lee, Thos. D., Grate Mkr, 2430 Reese st
Leeds, Joseph S., Draughtsman, 500 N.
Broad st

Leeds, Josiah W., Real Estate, 528 Wal-
nut st

Leeds, Wilmer P., Teacher, 210 York st,
Camden, N. J.

Lehman, B. N., Teacher, Wayne av and
School Lane, Germantown.

Lejee, Wm. R., Broker, 1801 Walnut st
Lemolne, L. R., Mgr Yale & Towne Mfg
Co., 15 N. 6th st

Leunig, Chas., Wools, 112 S. Front st

- Leser, F., Banker, 1700 Tioga st
 Lesley, Joseph, 309 Walnut st, care of
 Townsend, Whelen & Co.
 Lessig, Theo., Florist, Harrowgate st,
 Phila.
 Levering, Wm. M., Pres, 218 S. 4th st
 Levy, Louis E., Photo-Engraver, 7th and
 Chestnut sts
 Lewis, Enoch, Purchasing Agt, 233 S. 4th st
 Lewis, Frederick H., Room 135, Bullitt
 Building
 Lewis, Geo. F., Plate Printer, 33 S. 3d st
 Lewis, Harold R., Oils, 115 N. 2d st
 Lewis, John T., Mer, 231 S. Front st
 Lewis, Nelson A., 1314 Spruce st
 Lewis, S., M.D., 1332 Spruce st
 Lewis, Wilfred, Mech, 33d st and Powel-
 ton av
 Lewis, Wm. J., C.E., San Francisco, Cal.
 Le Van, W. B., Eng, 3607 Baring st
 Lieder, A. J. B., Atty-at-Law, 921 N. 4th st
 Lightfoot, Jesse, Lawyer, 6 Harvey st, Gtn
 Lillie, S. M., P. O. Box 49, Phila.
 Lindsay, Robert, Publisher, 1601 Green st
 Linville, Celeste V., 3314 Arch st
 Linville, J. Hays, Eng Arch, 3610 Walnut st
 Linville, S. P., 3114 Arch st
 Lipman, H. L., Stationer, 136 N. 10th st
 Lippert, Agnes M., 2015 Ridge av
 Lippincott, Alice, 509 S. Broad st
 Lippincott, Ezra, Importer, 303 Cherry st
 Lippincott, Howard W., Broker, 306 Stock
 Exchange pl
 Lippincott, J. Dundas, 509 S. Broad st
 Lippincott, Joshua, Clothier, 538 N. 6th st
 Livesey, John
 Lockwood, E. M., 481 N. 5th st
 Lloyd, Mrs. R., Colonnade Hotel
 Long, J. H., Mer, 527 Market st
 Longacre, Matthias R., Engraver and
 Lithographer, 13th & Market sts
 Longstreth, Edw., Mach, 1805 Sp. Garden st
 Longstreth, Charles, 1805 Sp. Garden st
 Loper, Capt. R. F.
 Lorenze, John, M.E., 244 S. 8th st
 Loring, E. B., 28 School st, Boston, Mass.
 Loss, Henry W., Pencoyd Iron Works,
 Pencoyd, Pa.
 Loudenslager, J. L., Bkpr, 430 Spruce st
 Love, J. H., Druggist, 3742 Market st
 Love, Robert, 56 N. 7th st
 Lovegrove, Thos. G., M.E., 143 N. 3d st
 Lowe, L. P., 333 Walnut st
 Lowe, T. S. C., Mfr, 333 Walnut st
 Lucas, John, Leads, Paints, etc., 141 N. 4th st
 Lucas, John, Inventor, 3304 Walnut st
 Lucas, John H., Grocer, 4100 Main st,
 Frankford
 Lucas, Wm. H., Paints, 1634 Arch st
 Luder, Thos. L.
 Ludlow, Edwin, Eng, Shamokin, Pa.
 Ludlow, Wm., Eng, Colonnade Hotel,
 Phila.
 Lukens, David L., Clerk, 2018 N. 8th st
 Lukens, Jawood, Iron Mfr, Conshohocken,
 Pa.
 Lungren, Chas. M., C.E., 1305 Locust st
 Luther, Rev. R. M., Secretary, 1128 Arch st
 Luthy, Otto, Chemist, 140 S. Delaware av
 Lutz, J. E., Lumber, 908 N. 16th st
 Lyndall, M. E., Teacher, 326 N. 11th st
 Lynn, John W., Pres. Elec Light, 426 S.
 Delaware av
 Lyon, C. Wesley, Chemist, 215 S. Front st
 Maas, Chas. E., Engraver, 610 Jayne st
 McCallum, Hugh, Mach, Germantown.
 McCoy, Alex. M., M.D., 1417 Walnut st
 MacFarlane, W. M., Chem, 110 Oxford st
 Maclean, Geo., 319 Walnut st
 Malon, Wm., Bkpr, 2507 Grays Ferry rd
 Magee, Jas. E., Conveyancer, 2640 Rich-
 mond st
 Magee, Michael, 1418 Arch st
 Magee, Frank H., Lawyer, 1219 Arch st
 Mahon, R. W., Mfr, 110 Arch st, Camden,
 N. J.
 Mahoney, C. A., Atty-at-Law, 908 Spruce st
 Maier, Gustav A., Tinsmith, 1937 N. 9th st
 Mancor, Frank G., Slate Mantels, 909 S.
 21st st
 Marcy, L. J., Optician, 1604 Chestnut st
 Maris, John M., Chemist, 711 Market st
 Markee, R. T., 1122 Green st
 Marks, Wm. D., Prof, 4304 Walnut st
 Maron, Alfred C., Confectnr, 1624 Green st
 Marriner, S. R., Carpenter and Builder,
 716 Cherry st
 Marset, Fred A., Math Ins, 830 Race st
 Marshall, Samuel R., Mach, 923 N. Broad st
 Martein, Jos., Imp, 227 Church st
 Martin, Jas., Jr., Mach
 Martin, Joseph
 Martinez, D. M., Com Mer, 237 Dock st
 Mass, Wm. A., Painter, 1021 Callowhill st
 Massey, G., Betton, M.D., 1502 Arch st
 Massey, W., Brewer, 10th and Filbert sts
 Matlack, David J., Iron, 1059 Richmond st
 Matlack, J. R., M.D., Race and Chester sts
 Mattheiu, J. A., Chemist, 815 Broadway,
 Camden, N. J.
 Matthews, C. L., Coal, 1713 Arch st
 Matthews, W. G., Coal, 1713 Arch st
 Mears, Wm., Plumber, 1906 Bainbridge st
 Meatyard, E. B., C.E., Lake Geneva, Wis.
 Megargee, Chas., Papr Dlr, 6th & Jayne sts
 Melchor, Martin V. B.
 Mellor, Alfred, Pres, 218 N. 22d st
 Melville, Anna F., Phila. P.O.
 Merchant, Clarke, Metal Dealer, 525 Arch st
 Merchant, Henry W., Mer, School Lane
 and Morris st, Germantown, Pa.

Merrick, J. Vaughn, Roxborough, Phila.
 Merrick, Wm. H., Mach, 220 S. 3d st
 Merrillhew, F., Coal, Shackamaxon st Whf
 Merriman, DeF. H., Mer, Williamsport, Pa.
 Merritt, Jas. Smith, Abington, Montgomery Co., Pa.
 Meschter, J. K., Incubators, 2433 N. 6th st
 Messchert, M. H., Lawyer
 Metzger, F. F., Inst. Mkr, 303 Buttonwood st
 Metzler, C. E., Sta Agt, 55 Herman st, Gtn.
 Meyer, Chas. E., Piano Dealer, 1717 Chestnut st
 Michener, J. H., Prest, 122 Arch st
 Mickle, C. C., Clerk, 23 Jay st, New York.
 Middleton, Adolph W., M.D., 860 N. 6th st
 Middleton, C., Iron, 2d and Willow sts
 Middleton, C. W., Iron, 945 Ridge av
 Middleton, H. W., Iron, 945 Ridge av
 Middleton, Nathan
 Miles, F. B., Mfr, 24th and Wood sts
 Miller, A. G., Mach, 420 Library st
 Miller, D. K., Lock Mfg, 420 Library st
 Miller, E. W., Bookbinder, 1718 N. 15th st
 Miller, J. H., Steam Eng, 1226 S. 31st st
 Miller, Jas. H., Brass Fdr, 1028 Sp. Garden st
 Miller, Lewis, Machy, 1821 N. 15th st
 Miller, Thos. S., Steam Eng, 1226 S. 31st st
 Milligan, C. T., Optician, 728 Chestnut st
 Mills, Chas. K., M.D., 1909 Chestnut st
 Milne, Caleb J., Mfr, 2030 Walnut st
 Milne, F. F., 1714 Spruce st
 Mingus, P. P., Blacksmith
 Mink, D. D. C., Freight Agt, 2108 Arch st
 Mintzer, S. J. W., M.D. 1036 Race st
 Mirkle, T. H., Jr., Drftsmn, 1212 Spruce st
 Missimer, J. H., Salesman, 2039 N. 13th st
 Mitchell, Harvey J., Mach, Hatboro, Montgomery Co., Pa.
 Mitchell, Henry F., 210 N. 34th st
 Mitchell, J. Henry, 1361 Ridge av
 Mitchell, W. A., Mer, 23d and Hamilton sts
 Montgomery, T. J., Atty-at-Law, 1815 Delancy pl.
 Moody, Edward F., Camden Safe Dep Co., Camden, N. J.
 Moore, Barclay, Div Oprtr, 558 Beacon st, Camden, N. J.
 Moore, Frank, Stenell Cutter, 27 S. 3d st
 Moore, Geo. R., Minister, 107 Green Lane, Roxborough Phila.
 Moore, H. D., Jr., 4028 Green st.
 Moore, Jas., Mach, 16th and Buttonwood st
 Moore, Samuel E., Bricklyr, 1029 Filbert st
 Moore, Thos., Mer, 529 Welsh st, Chester
 Moore, Wm. J., Carpenter
 Morgan, Thos. A.
 Morris, Henry G., Eng, 209 S. 3d st
 Morris, J. Cheston, M.D., 1514 Spruce st
 Morris, Israel, 1608 Market st

Morris, Israel W., 228 S. 3d st
 Morris, J. T., Mfr, Richmond and Ball sts
 Morris, Wistar, 3d and Walnut sts
 Morrison, Andrew J., Asst Supt Public Schools, 713 Filbert st
 Morrow, Henry W., 808 Market st, Wilmington, Del.
 Morrow, Wm. H., M.E., 656 N. 15th st
 Morse, E. L., M.E., Girard House
 Morse, Stephen A., Mach, 1105 Frankford av
 Morton, Henry, President Stevens Inst., Hoboken, N. J.
 Morton, Rev. Henry J., 909 Clinton st
 Morton, Sidney, Spinner, 1816 S. 8th st
 Morton, Thos. S. K., M.D., 1421 Chestnut st
 Mowlds, Thos. D., Lawyer, 209 S. 5th st.
 Mucklé, J. S., Mfr, 608 Chestnut st
 Mucklé, M. R., Gen'l Mgr, 600 Chestnut st
 Mucklé, M. Richards, Jr., Mfr, 608 Chestnut st
 Muhr, Jos., Jeweler, 224 S. 5th st
 Muller, Carl, C.E., 153 N. 15th st
 Murphy, Wm. C., Painter, 181 S. 2d st
 Murray, Chas. W., Stereotyper
 Murray, Matthias, Mach.
 Murray, Samuel A., Jr., Optician, 2206 Mt. Vernon st
 Murgatroyd, John, 1920 N. 23d st
 Murta, John P., Accountant, 249 S. 8th st
 Myers, S. C., Mach, 216 N. Broad st
 Myrick, Gilbert S., Supt, 3103 Chestnut st
 McAllister, W. M., Optician, 728 Chestnut st
 McArthur, John, 408 S. Broad st
 McArthur, John, Jr., Architect, Broad and Market sts
 McCabe, P., Chemist, 1232 Ogden st
 McCaffrey, Hugh, File Mfr, 1711 N. 4th st
 McCaffrey, John, File Mfr, 317 Diamond st
 McCall, Geo., Eng, 1610 Locust st
 McCallion, R. W., Formn, 1228 Christian st
 McCambridge, Richard, Brass Fdr, 527 Cherry st
 McCambridge, Samuel, Sdlr, 523 Cherry st
 McCarter, Wm., Painter, 256 S. 5th st
 McCauley, L. G., Eng, West Chester, Pa.
 McCausland, Wm. J., Mfr, 132 Market st
 McClees, Levi B., Mer, 1026 Arch st
 McClellan, J. M., Eng, 144 Maplewood av Gtn.
 McClintock, J. Y., C.E., 206 N. 3d st
 McClure, Jas. T., C.E., 811 N. 20th st
 McClure, Samuel C., M.D., care of Wm. M. Meredith, Equitable Bldg. New York, N. Y.
 McCollin, Jas. G., Secretary, 220 S. 4th st
 McCollin, S. M., M.D., 1128 Arch st
 McCollin, Thos. H., Photo Supplies, 624 Arch st
 McCollom, T. C., U. S. Navy Yard, League Island, Phila.

- McConnell, Jacob Y., Draughtsman, Woodlands av and 73d st
- McCormack, Jas., Grocer, 1201 South st
- McCowan, John
- McCurdy, J. C., Mgr, 7th and Chestnut sts
- McCurdy, J. R., Mfr
- McCutcheon, W. H., Oil-Cloth, 522 Arch st
- McDevitt, Wm., Insurance Patrol, Phila.
- McDowell, F., Bkpr
- McDowell, F. W., 28 S 6th st
- McDowell, John, Carpenter, 626 Filbert st
- McDowell, Stewart H., Chem, 35th st and Grays Ferry rd
- McDuffee, J. J., Mer, 4303 Walnut st
- McEachren, Jno. W., Mach, 528 Pearl st, Cleveland, O.
- McFadden, Wm. H., C.E., 13th and Sp Garden sts
- McFarland, Jas. P., Mer, 1023 Market st
- McFarland, W., Pattern Mkr, 322 N. 23d st
- McFetridge, John R., Printer, 306 Chestnut st
- Mellhenny, John, Gas Mtrs, 1116 Cherry st
- McIlvaine, A. Robinson, Drug and Sp. Mill, 15th and Hamilton sts
- McIlvaine, Wm.
- McIntyre, C., House Carpenter, Easton, Pa.
- McIntyre, C. S., Teacher, 1620 Latonia st
- McKee, Alex., Mach, 1409 N. 9th st
- McKean, W. V., Mgr *Ledger*, 6th and Chestnut sts
- McKelway, Geo. I., Brkr, 1410 Chestnut st
- McMurray, Andrew S., M.D., 1910 Christian st
- McNab, J., 721 Carmen st, Camden, N. J.
- McNiece, Wm., Mfr, 515 Cherry st
- Nacke, A., C.E., N. E. cor. 10th and Filbert sts
- Naylor, Jacob, Iron Fdr, Front st and Girard Ave
- Neal, Wm., 535 N. 7th st
- Nebinger, A., M.D., 1018 S. 2d st
- Needles, Samuel H., Mfr, Franklin Inst
- Negus, J. Engle, Mer
- Neisser, J. S., Tailor, 2417 Frankford av
- Nell, Geo. W., Printer, 437 N. 7th st
- Nelms, Henry, Gold Beater, 46 N. 7th st
- Neumann, Jos., Mfr, 919 Race st
- Nevil, Wm. H., Mfr, 144 Margaretta st
- Newbold, T. M., Pharmacist, 608 S. 42d st
- Newhall, Geo. M., Sugar Ref, 225 Church st
- Newlin, Jno. S.
- Newman, Jno. S., Jeweler, 433 Green st
- Newton, C. C., 2341 Callowhill st
- Nicholson, C. L., Lumber, 812 Wash. av
- Niehaus, Aug., Eng
- Nixon, Geo., Jr., Steam Heat, 21 N. 17th st
- Nohlit, J. H., 1319 N. Broad st
- Noek, Geo. W., Pres Penna. Mfg Co., 1714 S. 3d st
- Norris, Chas., 507 S. Broad st
- Norris, Geo. L., 222 W. 2d st, Wilmington, Del.
- Norris, Isaac, Lawyer, 1424 Walnut st
- Norris, Isaac, Jr., M.D., 1424 Walnut st
- Norris, Isaac, 3d, Student, 1424 Walnut st
- Norris, Thaddeus, Eng, 229 S. 18th st
- Norris, Wm. H., 3237 Powelton av
- Nugent, E., Druggist, Washington Hotel, Chestnut st above 7th
- Nunemacher, Henry B., M.D., Penna Hospital for Insane
- Nutz, Geo. W., care of Graphic Process Co., Pleasantville, N. J.
- Oat, G. R., Coppersmith, 1307 Arch st
- Oat, Jos., Coppersmith, 232 Quarry st
- Oatley, Dr. Eugene L., 4003 Chestnut st
- Ober, Thos. K., Mgr Sgr Ref, 1617 N. 16th st
- O'Connell, John, Mfg Dyer, Camden, N. J.
- Odenatt, W. H., Millwright, 2223 E. York st
- O'Driscoll, C. F., Stereotype Fdr
- Off, Henry C., Grocer, 261 S. 20th st
- Offrell, Oloff, M.E., 32 N. 11th st
- Ogden, Jno. L., Water Dept, 72d and Greenway av
- Ogelsby, W. P., Plumber, 1017 Walnut st
- Oldach Frederick, Bkbnr, 1215 Filbert st
- Oliver, G. L., 1412 Arch st
- Olsen, T., M.E., 1958 N. 11th st
- Onderdonk, Chas. S., Mgr, 121 N. 4th st
- O'Neill, Emmett, Gas Fitter, 4219 Frankford av
- Ormrod, Geo., Allentown, Pa.
- Orum, M. L., Mach, 448 N. 12th st
- Ott, G. F., Coppersmith, 213 Buttonwood st
- Ottinger, S. J., Telegrapher, 608 Parrish st
- Ourt, L., Bk and Whtsmith, Riverton, N. J.
- Outerbridge, A. E., Jr., Chem, 241 S. 13th st
- Packer, Edw., E., M.E., 3613 Ludlow st
- Page, D. L., M.D., 1124 Vine st
- Paige, F. E., Stationer, 1312 Filbert st
- Palen, Edward F., Mfr, 1529 Arch st
- Palen, Dr. G. E., 1529 Arch st
- Palmer, B. F., Surg Artist, 1609 Chestnut st
- Palmer, T. C., Chemist, 22 N. Front st
- Pancoast, Henry B., Mer, 243 S. 3d st
- Pancoast, S., M.D., 917 Arch st
- Pape, Richard, Mach, 2635 Girard av
- Pardee, A., Coal, Hazleton, Pa.
- Pardee, A., Jr., Iron, 237 S. 3d st
- Pardee, Calvin, Coal, Hazleton, Pa.
- Parham, Chas., Mach, 712 Cherry st
- Parker, G., House Carpenter, Mikleton, N. J.
- Parker, J.
- Parker, W. H., Teacher, 2024 Marvine st
- Parkinson, R. B.
- Parrish, Joseph, M.D., Burlington, N. J.
- Partz, A. F. W., M.E., 714 N. 43d st
- Partz, J. L., M.E., 714 N. 43d st

Parvin, A. B., Mer, 125 S. Front st
 Paterson, Wm., Draughtsman, 1206 Ring-
 gold st
 Patterson, A. H., Clerk, 419 N. 6th st
 Patterson, J. C., C.E., 1919 Spruce st
 Patterson, Robert, Treas, 329 Chestnut st
 Patterson, Wm. H., Lawyer, 49 S. 3d st
 Patton, R. H., Mach, 4307 Terrace st, Myk
 Patton, T. R., Mer, 1308 Pine st
 Paul, Jas., M.D., 1608 Walnut st
 Paxson, Edward J., Conveyancer, 735
 Walnut st
 Payne, J. A., 1232 Sp. Garden st
 Pease, Frederick M., Chemist P.R.R.,
 Altoona, Pa.
 Peltz, P. G., Eng U.S.N., Schuylkill Falls
 Pemberton, Clifford, Jr., 1947 Locust st
 Pemberton, Henry, 1947 Locust st
 Pemberton, Henry, Jr., Chemist, 1947 Lo-
 cust st
 Peady, Henry W., 191 Canal st, New
 York
 Pennoek, E., Salesman, 924 Chestnut st
 Pennoek, Geo. L., Mfr, Lansdowne, Pa.
 Pennoek, J. Sellers, Plumber, 33 N. 7th st
 Penrose, Chas. B., Eng, 1331 Spruce st
 Pepper, Geo. S., Atty-at-Law, 906 Wal-
 nut st
 Pepper, David, 1827 Spruce st
 Perkins, A. R., Mer, 102 S. 9th st
 Perkins, F. M., M.D., 1428 Pine st
 Perkins, Geo. H., Mfr, 413 S. Broad st
 Perkins, Mrs. H. C., 113 S. Broad st
 Perot, Chas. P., Com Mer, 259 N. Broad st
 Perot, E. S., Clerk, 519 Arch st
 Perot, T. Morris, Druggist, 1810 Pine st
 Peterson, Henry, Mach, Midvale Steel
 Works, Nicetown, Phila.
 Peterson, Jacob E., Sec, 431 Walnut st
 Petraeus, C. V., Chem, 231 S. Front st
 Pettit, Henry, C.E., 118 S. 19th st
 Pettit, Horace, Atty-at-Law, 518 Walnut st
 Peuckert, Kurt, M.E., 802 N. 10th st
 Pfahler, W. H., Supt, 2025 Park av
 Phillips, Chas. C., 2409 Park av
 Phillips, Cyrus, Chemist, 820 Arch st
 Phillips, G. Brinton, Chemist, 8 N. 7th st
 Phillips, J. S. W., 227 Chestnut st
 Phillips, W. J., 113 S. Broad st
 Pierce, Parker D., Salesman, 1326 S. 7th st
 Piers, Louis J., Accountant, 1201 Green st
 Pike, Chas. F., Mach, 1625 Francis st
 Pile, Gustavus, Druggist, 470 Passyunk av
 Pistor, Philip, Draughtsman, 2127 N. 12th st
 Platt, Chas., 232 Walnut st
 Pleasanton, Gen. A. J., 918 Spruce st
 Plumley, Thos., Eng, 3511 Lancaster av
 Pole, Benj. C., Eng., 150 S. 4th st
 Pommer, J. F., S. E. 17th & Mt. Vernon sts
 Ponton, John, Correspondent, Titusville, Pa.
 Pontzen, Ernest, Paris, France

Posselt, E. A., Principal Textile School,
 2602 N. 11th st
 Potts, Joseph D., Prest, 234 S. 4th st
 Potts, Serena M., 1309 Arch st
 Potts, Wm. M., C.E., Barneston, Chester Co.
 Powell, John M., 516 S. Delaware av
 Powell, Milton, Clerk, 233 N. 18th st
 Powell, W. B., Architect, 2326 Walnut st
 Pratt, Daniel R., Mach, Worcester, Mass.
 Pratt, F. A., M.E., Hartford, Conn.
 Price, E. K., Atty-at-Law, 709 Walnut
 Price, Isaac C., Atty-at-Law, 51 N. 7th st
 Price, J. S., Lawyer, 709 Walnut st
 Price, Jos.
 Price, Wm. S., Atty-at-Law, 633 Walnut st
 Prince, Samuel F., Jr., Mer, 2214 Chestnut st
 Proctor, Wallace, Apothecary, 900 Lom-
 bard st
 Pursell, Isaac, Architect, 119 S. 4th st
 Purves, A., Mer, 17 South st
 Purves, Alex., Conveyancer, 331 Chest-
 nut st
 Purves, Chas., Mer, 17 South st
 Pusey, Joshua, Atty-at-Law, 905 Walnut st
 Pyle, Elmar A., Salesman, 67th and Eln-
 wood av, West Phila.
 Quigley, Jno. F., Contractor, Wilming-
 ton, Del.
 Ramke, Bernard, Chemist, 1623 S. 16th st
 Ramsay, R. H., Railway Supplies, 290 E.
 Chelten av
 Rand, Theo. D., Atty-at-Law, 17 S. 3d st
 Randall, A. H., Jr., Mach, 2412 N. 15th st
 Randolph, Wm., Clerk, Media, Pa.
 Randolph, Wm. C., Ivory Trnr, 243 Arch st
 Randolph, Wm. K., Box 249, Phila.
 Rawle, Francis, Atty-at-Law, 402 Walnut st
 Rea, U. Howell, Carpenter, 1731 N. 19th st
 Reany, Robert L., Mach, Ocean City, N. J.
 Redfield, John H., 216 W. Logan sq
 Redfield, Robert S., 1600 Callowhill st
 Reed, Henry H., Mer, 1425 Chestnut st
 Reed, Miss Mary, Teacher, 301 S. 8th st
 Rees, B. W., Upholsterer, 3724 Market st
 Rees, Chas. S., Mfr, 2225 Jefferson st
 Rees, H. C., Electrician, 720 Sansom st
 Reeves, Elwood
 Reeves, Samuel J., 614 Walnut st
 Rehfuess, Geo., Engr, 1316 S. Broad st
 Reid, A. H., Mfr, Barker st above 16th
 Reist, H. G., F and M Department, Har-
 risburg, Pa.
 Remsen, Geo. C., 815 Arch st
 Reynolds, Sheldon, Atty-at-Law, Wilkes-
 barre, Pa.
 Rhoads, Joshua, M.D., Jacksonville, Ill.
 Rice, Arthur L., Engraver, 702 N. 44th st
 Rich, Geo., Mach, 120 N. 6th st
 Rich, John, Mach, 120 N. 6th st

- Richard, G. W., Mfr
 Richards, John, 22d st ab Arch, Atlantic Works
 Richardson, C. F., Clerk, 8 Walnut st
 Richardson, C. H., Filbert st below 7th
 Richardson, David D., M.D., Almshouse
 Richardson, Geo. J., Firearms
 Richardson, W.H., Cornice Mkr, 158 Centre st, Manayunk
 Richmond, J. M., Iron Miner, 1208 N. 18th st
 Ridgway, John J., Jr., Atty-at-Law, 204 S. 7th st
 Ridgway, Thos., 1705 Walnut st
 Ridpath, J. W., Jenkintown, Pa.
 Rigby, G., Bookseller, 33 S. 10th st
 Riehle, Henry B., Scales, 9th st above Master
 Riley, Hartley, Shirt Mfr, 528 Commerce st
 Ringwalt, J. L., Journalist, 1218 N. 10th st
 Ringwalt, Rev. Roland, Mantua, N. J.
 Risley, Isaac, M.E., 22 Spruce st, New York
 Ritchie, C. D., Prsdnt, N. W. cor 10th and Chestnut sts
 Riter, Jno. A., Builder, 610 N. 10th st
 Rittenhouse, A., M.D., 2001 Marshall st
 Rittenhouse, B. F., Chem, 2001 Marshall st
 Rittenhouse, Henry N., Mfg Chem, 218 N. 22d st
 Roberts, Alfred R., 310 N. 33d st
 Roberts, Caleb C., 1118 Arch st
 Roberts, Chas., Mfr, 1716 Arch st
 Roberts, Geo. B., Pres. P.R.R. 1901 Spruce st
 Roberts, Geo. Theo., 314½ Walnut st
 Roberts, Percival, 265 S. 4th st
 Roberts, W. Milnor, C.E., Rio Janeiro, Brazil
 Robertson, Chas. W., Pumps, etc., 156 N. 5th st
 Robinson, A. Wayne, Clerk, 1926 Race st
 Robinson, E. W.
 Rodehausen, L., Wagon Bldr, 1432 N. 9th st
 Rodgers, W. C., 212 S. 9th st
 Rogers, Fairman, care of Dick Bros & Co., 147 S. 4th st
 Rogers, Henry A., Washington Hotel, 7th and Chestnut sts
 Rogers, J. S., Camden, N. J.
 Rogers, Wm. B., Treas and Vice-Prsdnt, 1000 Walnut st
 Rogers, W. H., Foreman, 722 N. 24th st
 Rohrman, Jos. B., Clerk, 610 Cherry st
 Rometsch, Wm. H., Loom Bldr, 2109 E. York st
 Rommel, John, 1409 Arch st
 Rominger, G. S., Supt, 20th & Wash. av
 Ronaldson, Chas. E., C.E., 4017 Locust st
 Rondinella, Lino F., M.E., 1912 Arch st
 Rosengarten, G. D., Chem, 1532 Chestnut st
 Rosengarten, H. B., Mfr, 325 S. 17th st
 Rosengarten, M. G., Chem, 1815 Spruce st
 Rosengarten, Samuel G., Chemist, 1532 Chestnut st
 Rosengarten, Wm., Mer, 1545 Sp. Garden st
 Rosenthal, Edwin, M.D., 517 Pine st
 Rosenthal, Jacob, 517 Pine st
 Rosenthal, Paul, Mfg Jeweler, 2132 Thompson st
 Rouse, J. G., 2011 Sp. Garden st
 Ross, A. Stoughton, M.E., E. Washington Lane, Gtn.
 Rothwell, C. R., Drftsmn, 1230 N. 18th st
 Rowan, Henry A., Mach, 322 Reed st
 Rowbotham, John, Mast Mech, N. Yard, 2506 N. Broad st
 Rowland, Edward, care of W. & H. Rowland, Phila.
 Rowland, W. L., care of H. Bower, Grays Ferry rd
 Rudolph, C. A., Manayunk
 Rudolph, W. K., C.E., 233 S. 4th st
 Rumpp, C. F., Mfr, 118 N. 4th st
 Ruschenberger, W. S. W., Med Director U.S.N., 1932 Chestnut st
 Russell, H. C., Clerk, 227 S. 4th st
 Russell, H. R., Teacher, Woodbury, N. J.
 Rutter, Chas. A., Patents, 424 Walnut st
 Ryan, Thos.
 Ryerss, R. W., Lawyer, 605 Walnut st
 Sadtler, S. P., Chemist, 204 N. 34th st
 Safford, Henry W., 1130 Girard st
 Safford, Thos. S., Mfr, 611 Commerce st
 Sailor, Henry, Marble Cutter
 Salmon, Chas. H., Mfr, Hancock and Oxford sts
 Salmon, W. W., C.E., Asst Supt N.P. Div, Lansdale, Pa.
 Sandgran, G. M., Plumber, 319 Wharton st
 Sanguinetti, Percy A., M.E., 1751 Park av
 Salom, Pedro G., Chemist, 208 S. 4th st
 Sargent, D. H., Phngprhr, 21st & Wash. av
 Sartain, Harriett Judd, M.D., 212 W. Logan sq
 Sartain, Henry, Plate Printer, 728 Sansom st
 Sartain, John, Engraver, 1346 N. Broad st
 Sartain, Paul J., M.D., 212 W. Logan sq
 Sartain, Samuel, Engraver, 212 W. Logan sq
 Sartain, Wm., Artist, 1346 N. Broad st
 Scattergood, Thos., 22 N. Front st
 Scattergood, Thos., Tanner and Currier
 Schaaß, John T., 219 N. Broad st
 Schaffer, Chas., M.D., 1309 Arch st
 Schamberger, Meyer, Chemist, 986 N. 7th st
 Schleicher, A. W., Eng, 33d and Walnut st
 Schleicher, Jas., Mer, 33d and Walnut st
 Schlessinger, Wm. M., Electrician, 4212 Chestnut st
 Schneider, Henry, Undertaker, etc., 1739 Germantown av
 Schnell, P. F. L., Chemist, Tacony Chem Works

Schrader, Henry, Mach, 2932 Cambridge st
Schreiner, Frederick, Compositor, 1224 N. 7th st
Schnbert, Robert, 221 S. 5th st
Schutte, L., Eng. 12th and Thompson sts
Schwab, Gus. A., Bkpr, 2661 E. Cumberland st
Schwarz, Paul W., Chem, care of Balbach & Son, Newark, N. J.
Scott, A. Victoria, M.D., 329 S. 12th st
Scott, Chas., Pres, 1028 New Market st
Scott, E. Alex., Stngrphr, 2013 N. 13th st
Scott, Geo. W., Mfr, Room 22, 302 Walnut st
Scott, T. Seymour, Mfr, 611 Commerce st
Seal, Lewis, Mer, 136 S. 3d st
Seal, W. T., Secretary, 106 Chestnut st
Seaman, H. J., Chemist, Catusanqua, Pa.
Search, T. C., Mfr, 106 Chestnut st
See, Horace, Eng, 1230 Spruce st
See, Richard C., Mer
Seiler, C., M.D., 1346 Spruce st
Sellers, Alex.
Sellers, Amelia
Sellers, Coleman, Eng, 3301 Baring st
Sellers, Coleman, Jr., Mach, 1600 Hamilton st
Sellers, Miss E. P.
Sellers, Horace W., M.E., 3301 Baring st
Sellers, Howard, 1600 Hamilton st
Sellers, Jno., Jr., Mach, 1600 Hamilton st
Sellers, Richard
Sellers, William, Eng, 1600 Hamilton st
Sellers, Wm. F., Edgemoor Iron Co., Wilmington
Seltzer, C. J., M.D., 23 S. 16th st
Semper, Dr. Conrad, Chem, 503 S. 41st st
Serrill, W. J., Darby, Delaware Co., Pa.
Sexton, Jno. W., Dry Goods, 112 S. 3d st
Shaffer, W. A., Tel Lineman, 1928 S. 11th st
Shaffer, W. C., E.E., 110 S. 3d st
Shain, Chas. J., 225 Atlantic av, Atlantic City, N. J.
Shapley, Ambrose, Sec, 151 S. 4th st
Sharp, Jos. M., Math Ins, 1327 Ellsworth st
Sharpe, W. E., Turner, 1223 Chestnut st
Sharpless, Henry G., Mer
Sharpless, J. T., M.D., 1227 Arch st
Sharpless, N. H., Lawyer, Washington sq and Locust st
Sharpless, S. J., 705 Walnut st
Sharpless, Wm. P., Mer, 2510 Arch st
Shaw, Henry G., Chem, Kalion Chemical Co., 21st st and Grays Ferry rd
Shaw, J. Elliott, 151 S. 4th st
Shaw, John Eyre, Atty-at-Law, 110 S. 4th st
Shaw, J. William, Architect, 233 S. 4th st
Shaw, Thos., Mach, 913 Ridge av
Shepard, H. Warren, Chem, 523 Linden st, Camden, N. J.
Sheppard, F., Lawyer, 717 Walnut st

Sheppard, Jos. R., Foreman, 2538 Norris st
Shimer, J. M. N., Iron Mer, 230 S. 4th st
Shinn, Jas. T., Druggst, Broad & Spruce sts
Shinn, John, Mach, 2734 N. 5th st
Shober, Jno. B., Men Stndt, 1311 Spruce st
Shoemaker, J. L., Bldr, 3109 Powelton av
Shoemaker, Julien, Pblshr, 717 Market st
Shoemaker, Nathan, Builder, 1931 Park av
Shoemaker, Robert, Jr., Glass Mer, 4th and Race sts
Shoemaker, Thos. H., 45 Tulpehocken st Gtn.
Shoffner, W. N., Com Mer, 1909 Market st
Shrives, C. D., Druggist, 1422 S. 13th st
Shrigley, John M., Mach, Lansdowne, Delaware Co.
Shulze, John A., Mer, Bingham House
Shuman, Frank, Chemist, 5412 Media st
Shunk, Emma A., Clerk, 520 N. 15th st
Sickle, Jas. F. C., Asst Supt Pub Schools, 637 N. 40th st
Silver, Jas. S., Coal Mer
Simons, G. W., Jeweler, 611 Sansom st
Simons, H., Jr., Wheelwright
Simons, Jno. F., Jeweler, 618 Chestnut st
Simons, M. P., Phtgrphr, 1320 Chestnut st
Simpson, G. W., 839 N. 11th st
Simpson, Wm. S., Uphlstr, 1930 Sansom st
Sinex, Thos. Merchantville, N. J.
Singer, Edgar A., Teacher, 4764 Penn st, Frankford, Pa.
Skidmore, S. T., Teacher, 17th and Sp. Garden sts
Slater, G. M., Mach, 2747 N. 11th st
Slifer, Frank F., 532 Arch st
Slifer, H. J., C.E., 4817 Lancaster av
Slifer, John J., Restaurateur, 635 Arch st
Slingluff, John, Banker, Norristown, Pa.
Slingluff, W. F., Cashier Montgomery Nat Bank, Norristown, Pa.
Sloan, J.
Sloat, G. B., Mfr, 2127 Park av
Smedley, A. M., Crpntr, 2012 Mt. Vernon st
Smedley, F.W., Mer, Room 22, 302 Walnut st
Smedley, Samuel L., C.E. and Surv, City Hall
Smedley, Walter, Architect, Media, Pa.
Smethurst, John, Fresco Painting, 1241 Ridge av
Smith, Benj., Accountant
Smith, B. R., Broker, 4717 Main st, Gtn.
Smith, Chas Broker, 47 S. 3d st
Smith, Chas. B.
Smith, Chas. E., Eng, 216 S. 15th st
Smith, Chas. G., M.E., 1716 Race st
Smith, Chas. W.
Smith, DeWitt W., Machy, 135 N. 8d st
Smith, Edwin, Mach, Ocean City, N. J.
Smith, E. M., M.D., 812 N. 8th st
Smith, Ephraim, Chemist, 1110 Pine st
Smith, Geo. F., Dry Gds, 133 South 11th st

- Smith, Henry W., Actuary Am Life Ins Co.,
' S. E. cor 4th and Walnut sts
- Smith, Isaac R., Mer
- Smith, Jas. Brown
- Smith, J. F., C.E., Reading, Pa.
- Smith, J. Harper, Mer, 1935 Bainbridge st
- Smith, John L., Map Pub, 27 S. 6th st
- Smith, J. Rundle, Broker, 1800 Spruce st
- Smith, Louis, Cabinet Mkr, 423 Wood st
- Smith, R. M., 1339 Spruce st
- Smith, R. Rundle, Atty-at-Lw, 202 S. 13th st
- Smith, Samuel, Druggist
- Smith, T., Carpntr, Eng, 3303 Hamilton st
- Smith, Walter, Mgr Elec Light Co., 11th
st bel Chestnut
- Smith, W. M., Mach, 211 Quarry st
- Smyth, Marriot C., 3307 Race st
- Snedecker, Jas., Mach, 3912 Aspen st
- Snider, Geo., Bookbndr, 2311 Sp. Garden st
- Snyder, Harrington, Stock Broker, 131 Hud-
son st
- Snyder, M. B., Teacher, 752 N. 19th st
- Somerset, E. M., 1207 Hamilton st
- Somerville, Jas. McA., M.D., 1714 Race st
- Souder, Chas. B., 1428 Callowhill st
- Spangler, H. W., Eng U.S.N., 603 S. 42d st
- Sparks, Thos. W., Clerk, 121 Walnut st
- Speel, Jos. L., Bkbndr, care of McDowell,
cor 5th and Mulberry sts
- Spellier, Louis H., Wtch Mkr, 809 Race st
- Spencer, J. A., Atty-at-Law, 423 Walnut st
- Speier, W. G., Clerk, 349 N. 3d st
- Spittall, John, Wood Engraver
- Stager, O. W., Supt Tel Co P. & R.R., Read-
ing, Pa.
- Stahl, Albert W., Asst Naval Constructor,
1604 Master st
- Stambach, S. P., Plum Sup, 56 N. 7th st
- Stamm, N. L., 233 S. 4th st
- Stanger, Harry, care of C. N. Thorpe & Co.,
19th and Brown sts
- Stanton, Wm. H., 322 Union st
- Starr, Edwin P., Strtypr, 324 Chestnut st
- Stavely, J. Thomas, Printer, 237 Dock st
- Stein, E., Pres, 21st st and Wash. av
- Stephens, Lemuel, Prof, Girard College
- Stern, Edward, Printer, 125 N. 7th st
- Stern, H. F., Printer, 125 N. 7th st
- Sternberger, Leopold, Shirt Mfr, 503 Mar-
ket st
- Stevens, Arthur L., Drftsmn, 11 S. 9th st
- Stevens, Ervin N., Drftsmn, 1305 Butler st
- Stevens, Geo. R., Mach, 1103 Frankford av
- Stenson, A. A., M.E., care of Columbia
Iron Co., Johnstown, Pa.
- Stevenson, John E., Mer, 3508 Baring st
- Stewardson, John, Architect, Chestnut
Hill, Pa.
- Stewart, Alex., Cashier, 224 S. 5th st
- Stewart, Chas., Bricklayer, 37 N. 7th st
- Stewart, Franklin
- Stewart, J. L., President, 1813 N. Broad st
- Stewart, S. M., M.E., 3041 Danphier st
- Stewart, Thos. S., Architect, 1031 Spruce st
- Stewart, Thos. S., Jr., M.E., 1031 Spruce
- Stirzel, Jacob W., Gas Fitter, 617 Arch st
- Stokes, Samuel E., Mach, 3001 Chestnut st
- Stover, Lewis, Atty-at-Law, 522 Walnut st
- Straube, Max, Teacher, 3900 Girard av
- Strawbridge, Dr. Geo., 1500 Walnut st
- Strawbridge, Jas. B., Chem, Lynchburg, Va.
- Stratton, Matthias
- Streeper, P. R., Miller, 1838 N. 11th st
- Strobel, Victor, Eng, 226 Walnut st
- Strohm, Samuel D., Dentist, 117 Laurel st
- Stroud, Wm. C., 2035 Mt. Vernon st
- Struthers, J. Strickland, Gas Office, 13th
and Sp. Garden sts
- Stuebner, Harry, Mach, 705 Vine st
- Sumner, John, Blacksmith, 531 N. 20th st
- Sundstrom, C. A., C.E., 15th and Market sts
- Suplee, H. H., 907 Arch st
- Sweatman, V. C. Pres, 1121 Arch st
- Sweetzer, Calvin, Phonographer, Bethle-
hem, Pa.
- Swire, Wm. H., Conveyner, 1824 Vienna st
- Tasker, Thos. T., Jr., Mfr
- Tate, Wm. J., 3520 Lewis st, Port Richmond,
Phila.
- Tatham, Edw., 1114 Spruce st
- Tatham, Geo. N., Jr., 1114 Spruce st
- Tatham, Henry B., Jr., Mfr, 226 S. 5th st
- Tatham, Jas., Mfr, 226 S. 5th st
- Tatham, Wm. P., Mfr, 226 S. 5th st
- Tatham, Wm., Metallurgist, 226 S. 5th st
- Taws, Henry, M., 1650 Vienna st
- Taws, Louis, M.E., 1235 N. Front st
- Taylor, Geo. W., 3728 Hamilton st
- Taylor, Henry, P., 640 N. 10th st
- Taylor, J. B., 705 S. 16th st
- Taylor, Stacy, House Carpenter
- Taylor, T. Chalkley, Chemist, 720 N. 44th st
- Taylor, W. Curtis, Photographer, 1328
Chestnut st
- Taylor, Wm. L., M.D., 1440 N. 12th st
- Teal, Peter, Mach
- Tengvall, Alex., M.E., 1716 Race st
- Terne, Dr. Bruno, Chemist, 20 S. Del. av
- Thackara, B., Mfr, 1300 Chestnut st
- Thackara, Chas., 1300 Chestnut st
- Thayer, R., 232 S. 22d st
- Thomas, A. W., Mfr, 803 Race st
- Thomas, J. V., Iron Master, Bellefonte, Pa.
- Thomas, Lancaster, Apothecary, 1941 Sp.
Garden st
- Thomas, N. Wiley, Chemist, 1513 Centen-
nial av
- Thomas, Wm. P., Sec, 2247 Richmond st
- Thomson, A. J., 64 N. 2d st
- Thomson, E., Chemist, 12 Henry av,
Lynn, Mass.

Thomson, Geo., Ster & Elec, 710 Filbert st
 Thomson, Dr. Wm., 1426 Walnut st
 Thompson, Benjamin, Tailor, P.O. Box 413, Phila.
 Thompson, Chas. T., Draughtsman, 1057 Richmond st
 Thompson, Daniel, Jr., Druggist, 33d and Haverford rd
 Thompson, David
 Thompson, E. O., Tailor, 908 Walnut st
 Thompson, E. O., Jr., Tailor, 245 Broadway, N. Y.
 Thompson, John J., 202 Spruce st
 Thompson, Thos., Stone Cutter
 Thompson, Wm. J.
 Thorne, Wm. H., Mach, 1600 Hamilton st
 Thorpe, Chas. N., Watch Case Mfr, 19th st ab Brown
 Thudlum, Wm. K., Mfr, 813 Franklin st
 Thurston, Prof. R. H., M.E., Cornell Univ, Ithaca, N. Y.
 Tilghman, B. C., Lawyer, 1114 Girard st
 Tilghman, B. C., Jr., 321 S. 11th st
 Tilghman, Edward, 520 Walnut st
 Tilghman, Richard A., 321 S. 11th st
 Tiller, Samuel, Copper Plate, 815 N. 15th st
 Titus, E. J., Palmyra, N. J.
 Todd, Wm. E., Mach, 1365 Beach st
 Toland, Geo. W.
 Tolman, Henry, Eng's Supplies, Wallingford, Pa.
 Tompson, Ambrose W.
 Torbenson, Viggo, Mach, 1410 Parrish st
 Towne, Henry R., Mfr, Stamford, Conn.
 Townsend, David, Eng, 1723 Wallace st
 Townsend, E. Y., Pres, 218 S. 4th st
 Townsend, Isaac, Mfr Agt, 203 N. 3d st
 Townsend, Jos. B., Lawyer, 709 Walnut st
 Townsend, L., Mfr, 329 N. 11th st
 Tracy, E., Watch Case Mfr, 700 Sansom st
 Truau, Adam, M.D., 934 N. 5th st
 Trautwine, John C., 3301 Haverford st
 Trimble, Henry, Chem, 632 Marshall st
 Troth, Samuel N., M.D., 2013 Franklin st
 Trotter, Wm. H., Mer, 36 N. Front st
 Truitt, Jos. P., Mfr, 218 N. Broad st
 Truman, Wm. H., Dentist, S. W. 9th and Spruce sts
 Tucker, Christopher, 141 N. 17th st
 Turnbull, Lawrence, M.D., 1562 Walnut st
 Turner, Ernest, Surveyor, 141 N. 20th st
 Turner, E. H., Electrician, 327 Federal st, Camden, N. J.
 Turner, Geo., Jr., Plumber, 1309 Wylie st
 Tuttle, David K., Melter & Ref, U. S. Mint
 Twibill, Thos., Lawyer, 6 Merrick st
 Twining, Robert Barclay, 522 Dilwyn st

Uhlund, Wm. H., Leipsig, Germany
 Uhlinger, W. P., Mach, 22 E. Canal st
 Uhlmann, Max, 816 Cherry st

Unger, John F., C.E., 1006 Mt. Vernon st
 Ulmer, Levi B., Mgr, 715 N. Delaware av
 Vail, Hugh D., 1927 Mt. Vernon st
 Van Artsdalen, J. T., Engv, 864 N. 8th st
 Vanhorne, M. K., Carver
 Van Kannel, Theoph., Mfr, P. O. Box 45, Phila.
 Van Lennep, Wm. B., M.D., 410 S. Broad st
 Van Stavoren, S. J., Sol Patents, 416 Walnut st
 Varney, Wm. W., Drftsmn, 1517 Centennial av
 Vaux, Geo., 1715 Arch st
 Vaux, Geo., Jr., Lawyer, 1715 Arch st
 Vernon, W. G., Mfr, 31st and Chestnut sts
 Verree, Jno. P., Iron Mfr, 939 N. Delaware av
 Victorin, Anthony, Watervliet Arsenal, West Troy, N. Y.
 Viennot, J., Journalist, 504 Walnut st
 Voigt, Chas. A., Violin Mkr, 225 N. 5th st
 Vollmer, Wm., Mach, 819 N. 8th st
 Voorhees, Philip R., 32 Nassau st, New York City.
 Waechter, L. W. F., 811 Randolph st
 Wagner, H. D., M.E., 1819 Spruce st
 Wagner, H. Dumont, Mach, 119 S. 4th st
 Wagner, Sam, Atty-at-Law, 1819 Spruce st
 Wahl, Emil, Mfr, 2333 N. 7th st
 Wahl, John H., 1436 N. 13th st
 Wahl, Wm. H., Ph. D., Sec Fr. Inst., 1436 N. 13th st
 Walanta, Edmund, Designer, 2232 N. Broad st
 Walder, John H., M.E., Gtn., Pa.
 Walker, Joseph H., Bkpr, 2036 Arch st
 Walker, Wm. Weightman, C. E., 112 S. 18th st
 Wallace, H. J., 405 N. 35th st
 Walliser, H. F., Silks, 619 Arch st
 Walter, Thos., Mfr, 1526 Wallace st
 Walter, Warner, Hardware, 1233 Market st
 Walter, Wm., Drover, 2916 Ridge av
 Walther, Frederick, Optician, 703 Thompson st
 Walton, C., Hardware, 625 Market st
 Walton, C. W., Mfr, 1713 Sp. Garden st
 Walton, Jesse S., Clerk, 233 S. 4th st
 Walton, Jos. J., Optician, 924 Chestnut st
 Wannamaker, John, Mer, 13th and Market st
 Wanich, Alex., Mach, 1059 Richmond st
 Ward, G. M., Gas Consumers' Benefit Co., 21 Jane st, New York
 Warden, Henry, Drftsmn, 18th and Allegheny av
 Warden, Wm. G., Ref of Petroleum, 307 Walnut st
 Warder, J. H., Eng, Wilmington, Del.
 Ware, Lewis S., Eng, Aldine Hotel
 Warner, Fannie V., Phonographer, 1610 Brandywine st

- Warner, R. S., M.E., 1526 Swain st
 Warren, E. B., Roofer
 Warren, Samuel D., Mer, 1 State st, Boston, Mass.
 Warrington, Jas., 218 Penn st, Camden, N. J.
 Watch, A. F., Optician, 1731 Filbert st
 Waters, D. A., Mfr, 3103 Chestnut st
 Watkins, J. E., Clerk, C. & A. R. R., Camden, N. J.
 Watson, James, Steam Apparatus, 144 N. 7th st
 Way, Albert M., Eng, S. E. cor 4th and Race sts, care of R. Shoemaker & Co.
 Weatherby, J. P., Cooper and Del. sts, Camden, N. J.
 Weaver, John, Stenogrphr, 2853 N. 11th st
 Weaver, John J., Plumber, 7th and Filbert st
 Webb, C. R., Mer, 519 S. 8th st.
 Webster, Geo. S., Eng, Kensington and Indiana sts.
 Webster, Wm. R., C.E., 424 Walnut st
 Weidner, C. A., Chester, Pa.
 Weightman, Dr. J. F., 9th and Brown sts
 Weightman, Wm., Chem, 9th & Parrish sts
 Weik, John, C.E., N. E. 44th & Wallace sts
 Weir, Jas. A., Hardware, 1421 Girard av
 Welsh, Ashbel, C.E., Lambertville, N. J.
 Welsh, Samuel, 304 Walnut st
 Werner, E. A., C.E., Chief Eng's Office, Louisville & Nashville R.R., 2d and Main sts, Louisville, Ky.
 West, Henry F., Mfr, Gloucester, N. J
 West, John, M.E., Bethlehem, Pa.
 Westesson, J. P. L., Chem, 208 S. 4th st
 Westinghouse, Geo., Jr., Mfr, Pittsburgh, Pa.
 Wetherill, Robert, Mach, Chester, Pa.
 Whartenby, Thos.
 Wharton, Jos., Nickel Works, 28 S. 3d st
 Wharton, Rodman, Eng, Clinton ab 9th st
 Wheeler, F. A., 127 Penn st, Gtn.
 Wheeler, Jos. K., 2026 Chestnut st
 Wheeler, N. W., Union Dry Dock, Buffalo, N. Y.
 Whelen, Ch. S., Broker, 309 Walnut st
 Whetstone, J. L., Mfr, 921 Filbert st
 Whitaker, Thos. D., Chem, 203 Church st
 White, Jos. J., 925 Market st
 White, Robert G., Designer, 2511 Frankford rd
 Whiting, J. H. C., Publisher, 154 S. 4th st
 Whitney, Asa W., Mfr, 16th and Callowhill sts
 Whitney, Chas. H., Mfr, 16th and Callowhill sts
 Whitney, Geo., Eng, 16th & Callowhill sts
 Whitney, Jas. S., Mfr, 16th & Callowhill sts
 Whitney, John R., Mfr, 16th and Callowhill sts
 Whitney, Louis B., Mfr, 16th and Callowhill sts
 Wickerman, Morris S., 217 S. 3d st
 Wickersham, J. B., Iron Mfr, 505 Cherry st
 Wiedersheim, J. A., Pat. Sol, *Record Building*
 Wiegand, Jno., Jr., Mach, 523 Arch st
 Wiegand, S. Lloyd, Eng, 146 S. 6th st
 Wigmore, W. N., Surg. Insts, 107 S. 8th st
 Wilbraham, Jno. S., Mfr, Main st, Frankford
 Wilbraham, Jno. W., Sr., Mach, 2518 Frankford av
 Wilcox, Austin O.
 Wilcox, Jas. M., Jr., Mfr, 509 Minor st
 Wilcox, Jos., 1810 Chestnut st
 Wilcox, W. F., Mfr, 509 Minor st
 Wilder, M. G., Mfr, 816 Cherry st
 Wiler, Wm., Mfr, 225 S. 5th st
 Wilkinson, Alfred, M.E.
 Wilkinson, Alfred, M.E., 3131 Dauphin st
 Wilkinson, Wm. J.
 Willard, E. M., Mer, 718 N. 40th st
 Williams, Henry S., Math Depot, N. E. cor 10th and Chestnut sts
 Williams, N. W., M.E., 710 N. 10th st
 Williams, A. B., C.E., 504 Marshall st
 Williams, A. Eugene, Eng, 710 N. 10th st
 Williams, Chas. B.
 Williams, Chas. B., Mer, 627 Market st
 Williams, E. D., Lawyer, 457 Marshall st
 Williams, Edward H., Mfr, 500 N. Broad st
 Williams, Thos., Jr., Atty-at-Lw, 1518 Pine st
 Williamson, John, Lumber, 45th and Lancaster av
 Williamson, J. D., Jr., Drftsmn, 1800 N. 16th st
 Williamson, Passmore, Conveyancer, 700 Arch st
 Williamson, Wm. C., Eng, Richmond and York sts
 Willitts, Alfred, Furniture, 1605 N. 17th st
 Willitts, Jas., Bricklyr, 1629 Mt. Vernon st
 Willitts, T., Mer, 152 N. 4th st
 Wills, Abner E., Supt Del. Riv Chem Wks, Bingham Honse
 Wilson, C. G., Hardware, 508 Commerce st
 Wilson, Chas. Howard, Telegrapher, Ham-monton, N. J.
 Wilson, E. H., Clerk, 431 N. 33d st
 Wilson, G. W., Carpenter, Haverford College P.O., Pa.
 Wilson, H. A., M.D., 1611 Spruce st
 Wilson, H. H., Treas, 331 S. 12th st
 Wilson, Jas., Optician, Wanamaker's, 13th and Market st
 Wilson, Jas. A., Clerk, 1906 Montgomery av
 Wilson, Jas. F., M.D., 1010 Race st
 Wilson, John, Eng, 23d and Columbia av
 Wilson, Jno. A., C.E., 435 Chestnut st
 Wilson, J. A. L., Secretary, 528 Walnut st

Wilson, J. L., C.E., 332 Northampton st,
Easton, Pa.
Wilson, Joseph M., C.E., Pres Fr. Inst.,
Drexel Building
Wilson, J. S., Draughtsmn, 816 Nectarine st
Wilson, W. C., Grays Ferry rd and 35th st
Wilson, Wm. H., 3301 Powelton av
Wilstack, Miss W. P., 1733 Walnut st
Windrin, Jas. H., Architect, 132 S. 3d st
Winsor H., Mer, 338 S. Delaware av
Witte, W. F., M.E., Springtown, Pa.
Wolbold, Henry, Shoe Mfr, 2551 N. 6th st
Woellper, David A., Lumber, 1892 Park av
Wolf, Edwin, Lamp Bk Mfr, 874 N. 5th st
Wolf, O. C., Architect, 1121 Arch st
Wolf, Theo. R., Prof Del.Col, Newark, Del.
Wolff, Geo. S., Chemist, 1123 Franklin st
Wolff, L., M.D., N.W. cor 12th & Chestnut st
Wolle, C. E., M.E., 1500 N. 7th st
Wourath, F. K., Furrier, 710 Arch st
Wood, A., Jr., Mfr, Conshohocken, Pa.
Wood, Ebenezer, Tailor, 1237 Girard av
Wood, Howard, Pres, 1016 Spruce st
Wood, J. F., 12th and Thompson st
Wood, Robert, Ornamental Iron, 17th and
Oxford sts
Wood, Thomas, Mach, 2106 Wood st
Wood, W., Mfr, 400 Chestnut st
Wood, W. W. W., Chief Eng U.S.N., 108
Walnut st

Woods, J., Nashville, Tenn.
Woods, O. E., Correspondent, 308 N. 11st st
Wright, C. A., Cards, 527 Arch st
Wright, J. J., 3130 Chestnut st
Wright, J. K., Oil Silk, 26th st ab Penna av
Wright, Jno. W., Lawyer, 1420 Pine st
Wright, Louis S., Mach, 1801 Wallace st
Wright, Peter, Electrician, 406 N. 21st st
Wurts, C. S., M.D. 1701 Walnut st
Wyckoff, E. S., M.D., 6th and Arch st
Wyckoff, Lieut A. B. U.S.S. Lancaster, care
B. F. Stevens, 4 Trafalgar sq, London,
Eng.
Wyeth, F. H., Druggist, 1412 Walnut st

Yarnall, Reuben, Jr., Mer, 115 S. 10th st
Yeager, Jno. C., Mer, 843 Franklin st
Yeager, Jno. C.
Yearsley, Warren, Chemist, 1414 S. 49th st
Yeaton, Wm. N., Mfr, 260 S. 5th st
Young, Geo. W., 1339 Buttonwood st
Young, Richard, Dstllr, Morton, Del. Co., Pa.

Zeigler, J. W., 636 N. 35th st
Zeiss, Chas. F., Electrician, 114 S. 15th st
Zentmayer, Chas., Optician, 3021 Girard av
Ziegler, Geo. J., M.D.
Zimmerman, John, Wvr, 2604 Frankford av
Zoellner, Jos., M.D., 342 N. 5th st
Zorns, Chalkley S., Milk Dir, 1507 N. 17th st

During the year ending September 30th, 1888, there were stricken from the membership roll, through death, resignation and non-payment of dues, 177 names, and there were added 92 names of new members.

T Franklin Institute,
l Philadelphia
F8 Journal
v.126

~~Physical &~~
~~Applied Sci~~
~~Series~~
~~---~~

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE

